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NATIONAL GEOGRAPHIC

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The 2011 Guide to Automotive Advancements

Electric Vehicles, Hybrids, Plug-in Hybrids and Fuel Cells – How to Navigate New Driving Technology

By M. Desmond Roth

The numbers drive home the stakes: by 2035, there will be an estimated 1.6 billion cars on the road throughout the world.[1] If every one of these cars was fueled by a gas engine, C02 emissions would reach an estimated 8.2 billion metric tons per year.[2]

Yet it's been estimated that if every one of those cars was powered by hybrid technology, combining an electric motor with a gas engine, those emissions could be cut nearly in half.[3]

Scientists today can agree that reducing gas consumption and relying on alternative fuel technology are critical to reducing greenhouse emissions and stabilizing the climate.

At the core of the latest advances is hybrid technology, which forms the foundation for next-generation cars powered by electricity, hydrogen and biofuels.

The Next Big Thing: Plug-in Hybrid

There will soon be a hybrid for nearly every driver's needs as costs and performance metrics compete with conventional gas engine vehicles. Toyota is launching 11 different hybrid models globally in two years starting from 2011, seven of which will be all-new, not merely the next generation of an existing model.

Going one step further is the Prius Plug-in Hybrid (PHV) which is currently the subject of an international 600-vehicle demonstration program which began about a year ago and will run until the vehicle goes on sale approximately this time next year.

Offering the latest technological innovations of the current Prius, the Prius PHV currently being demonstrated adds a high-capacity lithium-ion battery that enables the vehicle to travel up to 13 miles on electric energy only, and can be recharged by plugging into a standard 110v home electric outlet or a 220v charging station. The Prius Plug-in can operate in all-electric mode at highway speeds of up to 60 mph, producing zero emissions during

short commutes. When the EV-only portion of the battery is drained of power, the vehicle defaults into Prius-mode, with conventional hybrid gas-electric power delivery and a combined fuel economy of approximately 50 mpg.[4]

Emissions-Free in EV Mode, Stress-Free in Hybrid (HV) Mode

The Prius Plug-in Hybrid demonstration vehicle can be fully recharged with a household electric outlet of 110v in just 3 hours. With a 220v outlet, it takes just one and a half hours to fully recharge – ultimately allowing for emissions-free driving in EV mode and stress-free driving during out-of-town weekend trips in HV mode.

Now imagine driving an SUV that can drive 430 miles[5] per fueling, and releases nothing more than water. That's what current U.S. test drivers are experiencing with the Fuel Cell Hybrid Vehicle (FCHV-adv).

Relying solely on batteries and hydrogen, the FCHV-adv car is powered by the electrical energy created by the chemical reaction between hydrogen and oxygen, which forms zero-emissions water vapor that is passed out the tailpipe.

"It's no longer a question of will these plug-in and hydrogen vehicles happen or not. It's about how quickly the market will grow, and how big their numbers will get," says Tim Lipman, co-director of the University of California - Berkeley's Transportation Sustainability Research Center (TSRC).

Toyota plans on launching its fuel cell model no later than 2015, once all testing of safety and reliability features are complete.

Not Just Greener – Better

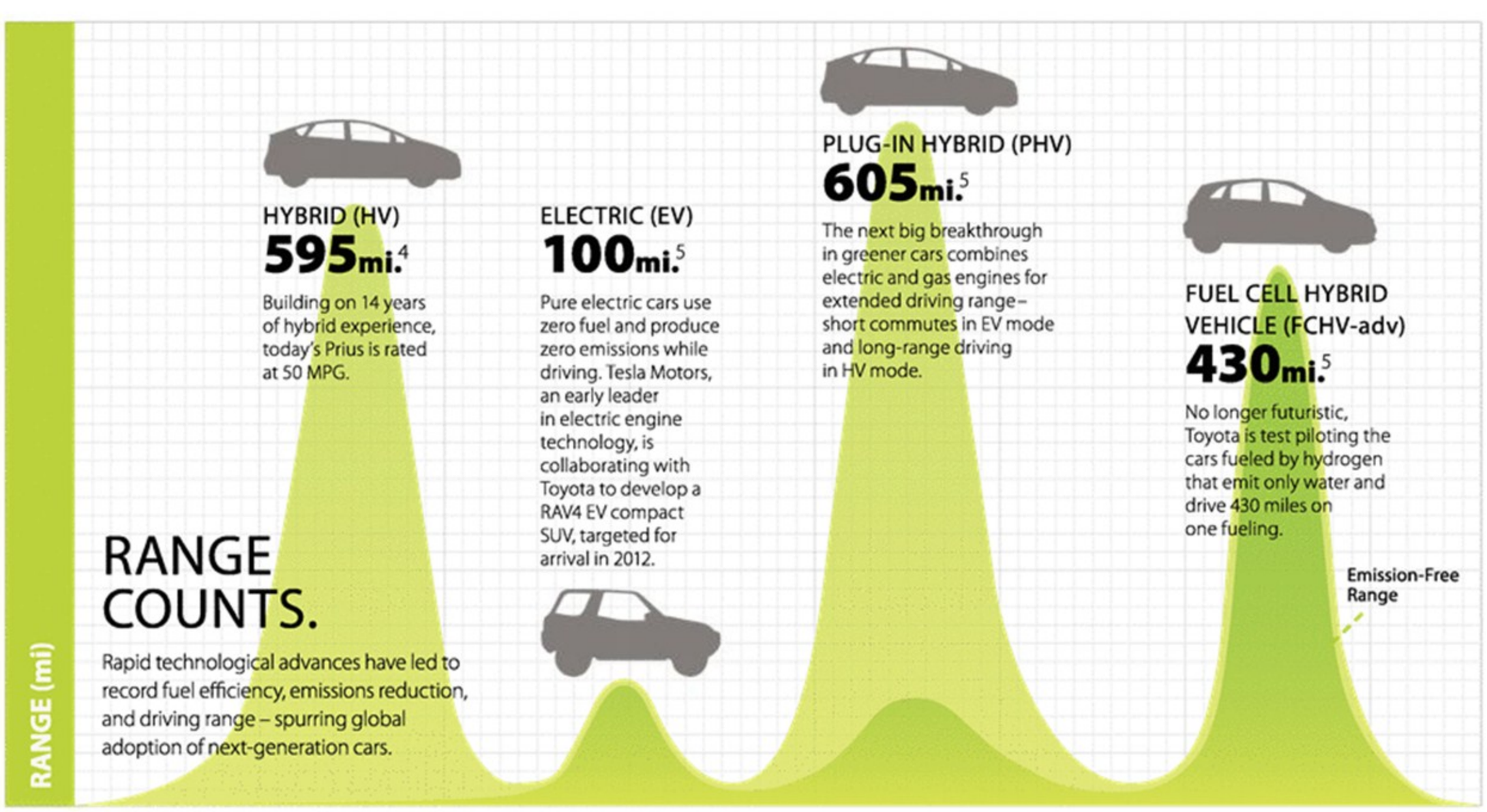
While the ecological benefits of the Plug-in Hybrid and Fuel Cell Hybrid Vehicle are generating excitement among environmentalists and government officials, the technology and practical advantages are helping build enthusiasm among test drivers around the world.

"Our studies tend to show that once people are exposed to these next-generation cars, their general impressions go up," says Lipman, who oversees a pilot program for the Prius Plug-in Hybrid and Fuel Cell Hybrid Vehicle.

After experiencing the fuel efficiency, quiet engines and smooth acceleration, test drivers report that the cars are not just greener – they're better.

"There's a market segment that will buy a clean car, but a much bigger market segment will buy a better car. That's where the prospects are good for these greener cars."

continue >>



4) 2011 EPA mpg estimates (combined). Actual driving range will vary.
5) All figures based on Toyota internal testing. Actual range and emissions will vary depending on conditions.

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The Road Ahead: Meeting the Needs of

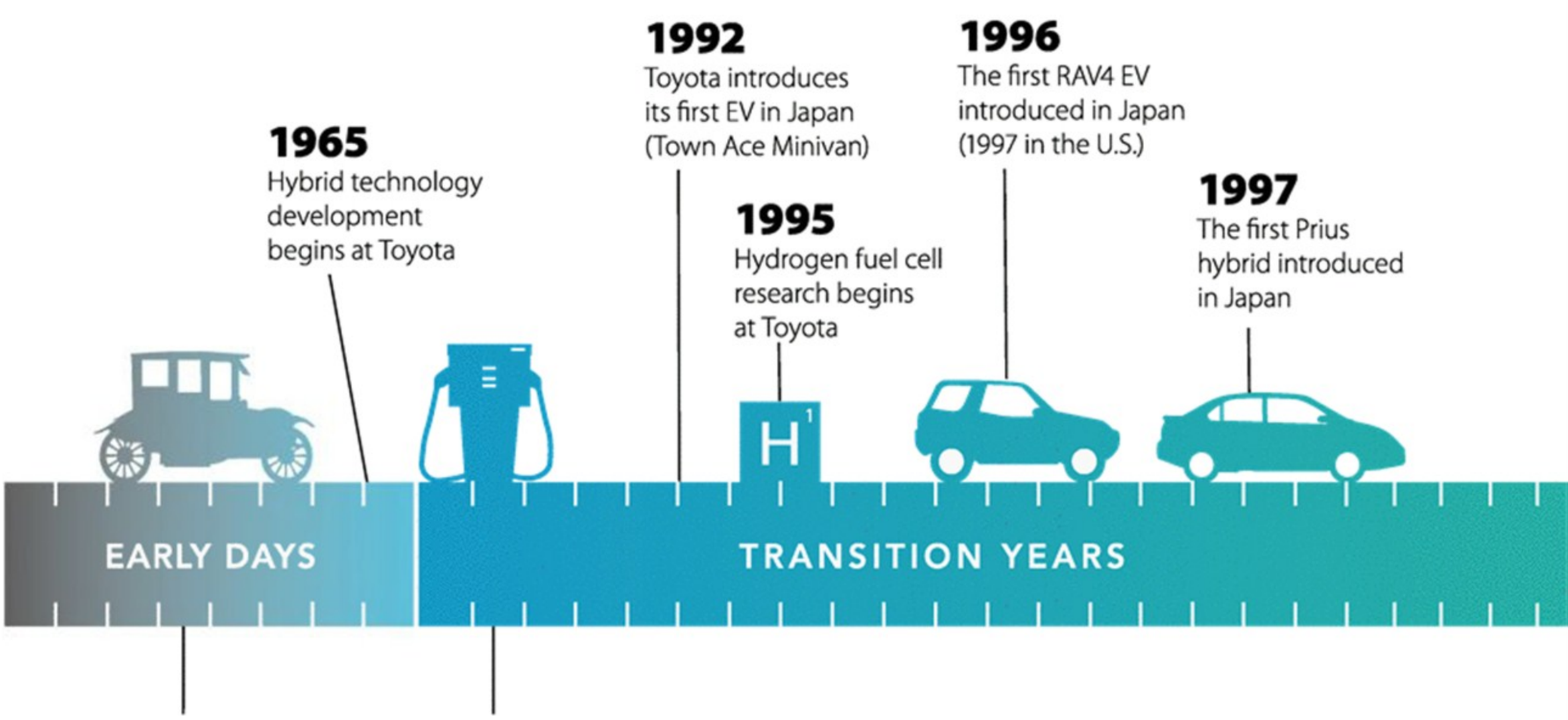
It may be hard to imagine, but over a century ago, sales of electric vehicles outstripped gas-driven car sales in the U.S.

At the turn of the 20th century, as many as 30,000 electric cars took to the roads, including a fleet of New York taxis. But when mass production of petroleum cars began in the early 1900s, electric cars simply couldn't compete. Gas-fueled cars cost half as much and could travel further and at faster speeds.

It would take six decades before electric cars would make their comeback, driven by the oil crisis of the 1970s, which set in motion two decades of experiments and futuristic new model launches. But the cars all came with limitations and costs that prevented them from catching on.

It wasn't until 1997, when the first Prius hybrid rolled onto the streets of Japan, that a practical eco-conscious car finally arrived. By bridging the gap between

The Evolution of Greener Cars:



SOURCES: *1) International Energy Agency (IEA). World Energy Outlook 2010, "Policies Scenario." Estimate is for total "passenger light-duty vehicles" on the road worldwide. 2) U.S. Environmental Protection Agency (EPA) estimates 5.10–5.20 metric tons CO_2 per vehicle-year for the average vehicle on the road today. Calculation: 1.6 billion cars multiplied by 5.15 metric tons equals 8.2 billion metric tons. 3) Estimates based on U.S. De-*

Tomorrow's Driver

electric and gas engines, the Prius became an immediate hit – selling more than 100,000 units with its first model and reaching the two million mark by 2009. The car soon became an international symbol of environmental progress.

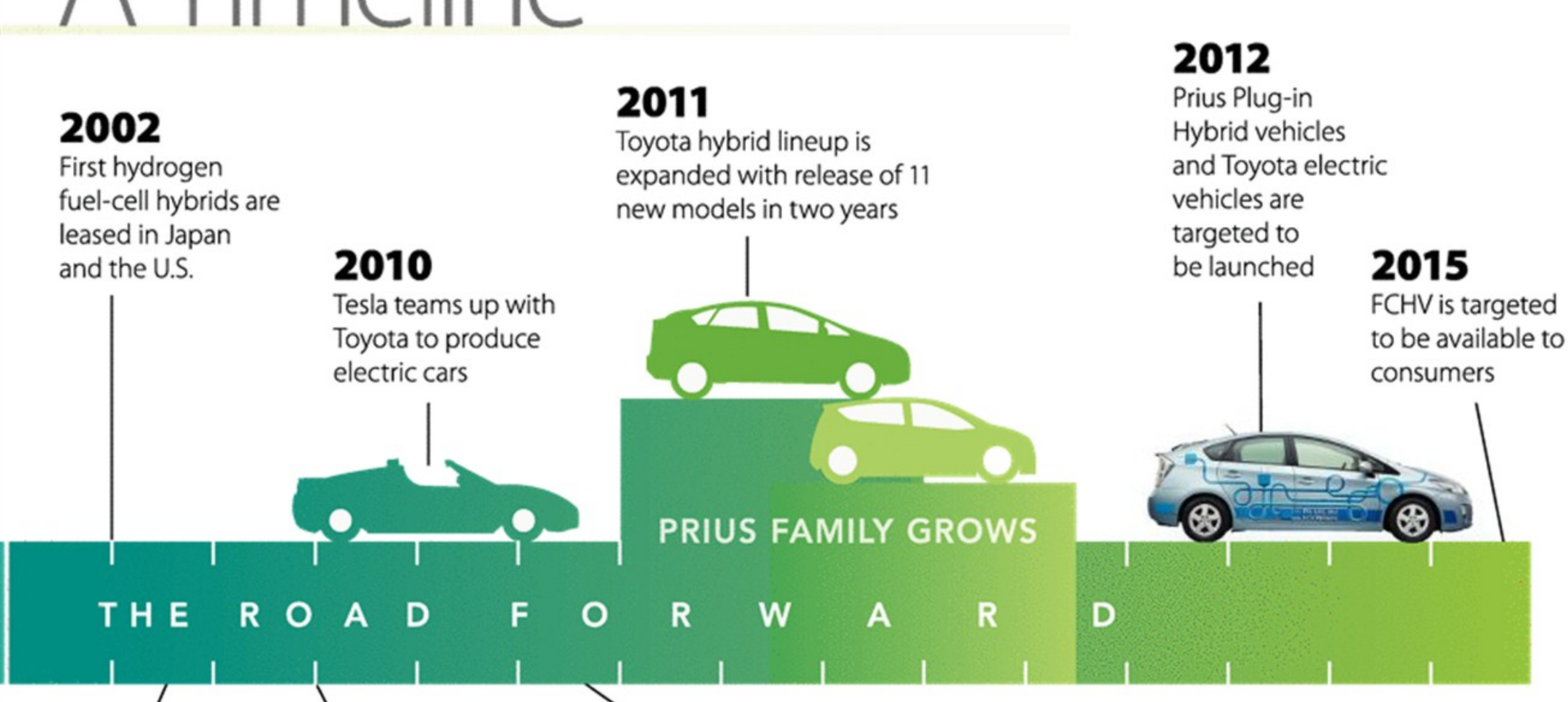
Today, the electrification of the passenger car is moving rapidly in many directions. Recent advances in lithium-ion battery technology have helped re-launch electric cars. Tesla Motors, an early leader in electric engine technology, is collaborating with Toyota to develop a RAV4 EV compact SUV, targeted for arrival in 2012.

Clearing the Horizon

In the end, in order to meet international fuel efficiency standards, "there has to be a massive global adoption of hybrids," says Bradley Berman, editor of HybridCars.com. For mass adoption to happen, consumers must have choices that are accessible and meet their daily needs.

Building on 14 years of advances in hybrid car technology, Toyota continues to pioneer the technological advances that expand choices to meet the needs of all people. The company's complete range of hybrid technology is at the core of plans to create eco-conscious cars across its lineup, each one moving us further away from dependency on gasoline, and each one improving the air we breathe. That will mean a clearer horizon for everyone.

A Timeline



partment of Energy (DOE), Argonne National Lab, GREET 2010 figures. 4) 2011 EPA mpg estimates (combined). Actual driving range will vary. 5) All figures based on Toyota internal testing. Actual range and emissions will vary depending on conditions.

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Sumatran Orangutan *(Pongo abelii)*
Size: Head and body length, approx. 0.75 - 1.5 m (29.5 - 59.1 inches) **Weight:** Males approx. 50 - 90 kg (110 - 200 lbs); females approx. 30 - 50 kg (66 - 110 lbs) **Habitat:** Primary lowland tropical rainforest in northern Sumatra **Surviving number:** Estimated at 7,300

Photographed by Thomas Marent

WILDLIFE AS CANON SEES IT

Person of the forest? That's what the word "orangutan" means, and in the case of the Sumatran orangutan it seems appropriate. After all, it has been observed using tools, once thought to be the exclusive domain of humans; it uses sticks to probe for termites or extract seeds from fruits, and even passes this knowledge on to the next generation. But as one of the world's slowest-breeding primates, giving birth just once every eight or nine years, it has few young. Faced with very rapid population declines and the shrinking and fragmentation of its range, this extraordinary orangutan is at risk of disappearing from the forest forever.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

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The sounds of war have been replaced by the sounds of children playing soccer on the grass.
page 82



First recognized as a breed in 1925 (and valued for its meat and fur), the Silver Fox is today a rare hare. Story on page 108.
JIM RICHARDSON

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Polar Meltdown
An interactive map shows how Arctic summer ice diminished from 1979 through 2010.

On the Cover
The real Cleopatra's face is a mystery. Our artist used a model who shares the ruler's Mediterranean heritage.
Art by Sam Weber

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Deep Roots

Regard for the land runs deep in photographer Jim Richardson's life. When he flies over the fields of Cornwall, England, he feels the pull of places his ancestors farmed. He's even visited the homestead of his Celtic ancestors, who lived when Anglo-Saxons arrived in what would become England. His parents were descendants of other immigrants, drawn to the Kansas plains, where they could farm on a scale unimaginable in England.

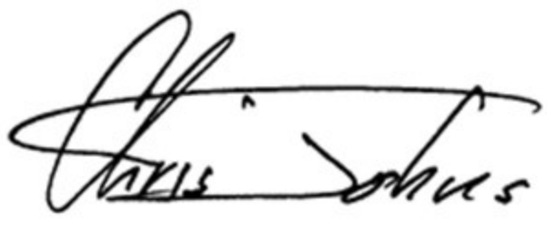
For Jim, love of the land is elemental.

Jim was not destined to continue his family's farming tradition. He was destined to document it, as this month's story on heirlooms shows. The article explains that the diversity of heirloom breeds is critical to ensuring our food supply and that a wide range of heirlooms is the best bet against disease and drought.



Cornwall kin of Jim Richardson gathered in 1882. The boy being held grew up to be Jim's grandfather.

Such themes resonate with Jim. "My emotional landscape is forever haunted by the imperative of rain, shaped in childhood by parents who wondered when it would rain, and if not—what would they do?" he said. "Some children fear divorce. I feared drought, the one thing that could destroy the security of a childhood life on the farm." For Jim, love of the land is elemental. Picture him in Ethiopia, seeing men harvesting oats by hand with sickles—a scene "straight out of some medieval tapestry," he says. Such hard work must be unrelenting drudgery, he thought. He got closer. "They were singing. This was the same land where hundreds of thousands died during the famine, yet there was joy in their voices and laughter." So Jim Richardson, who speaks the same language of the land as those harvesters, found himself laughing as well.





MAGAZINE OF THE YEAR

National Geographic won twice at the 2011 National Magazine Awards, receiving the "Ellie" (above) for best single-topic issue (April 2010's "The Water Issue") and for Magazine of the Year.

PHOTO: ROYAL INSTITUTION OF CORNWALL

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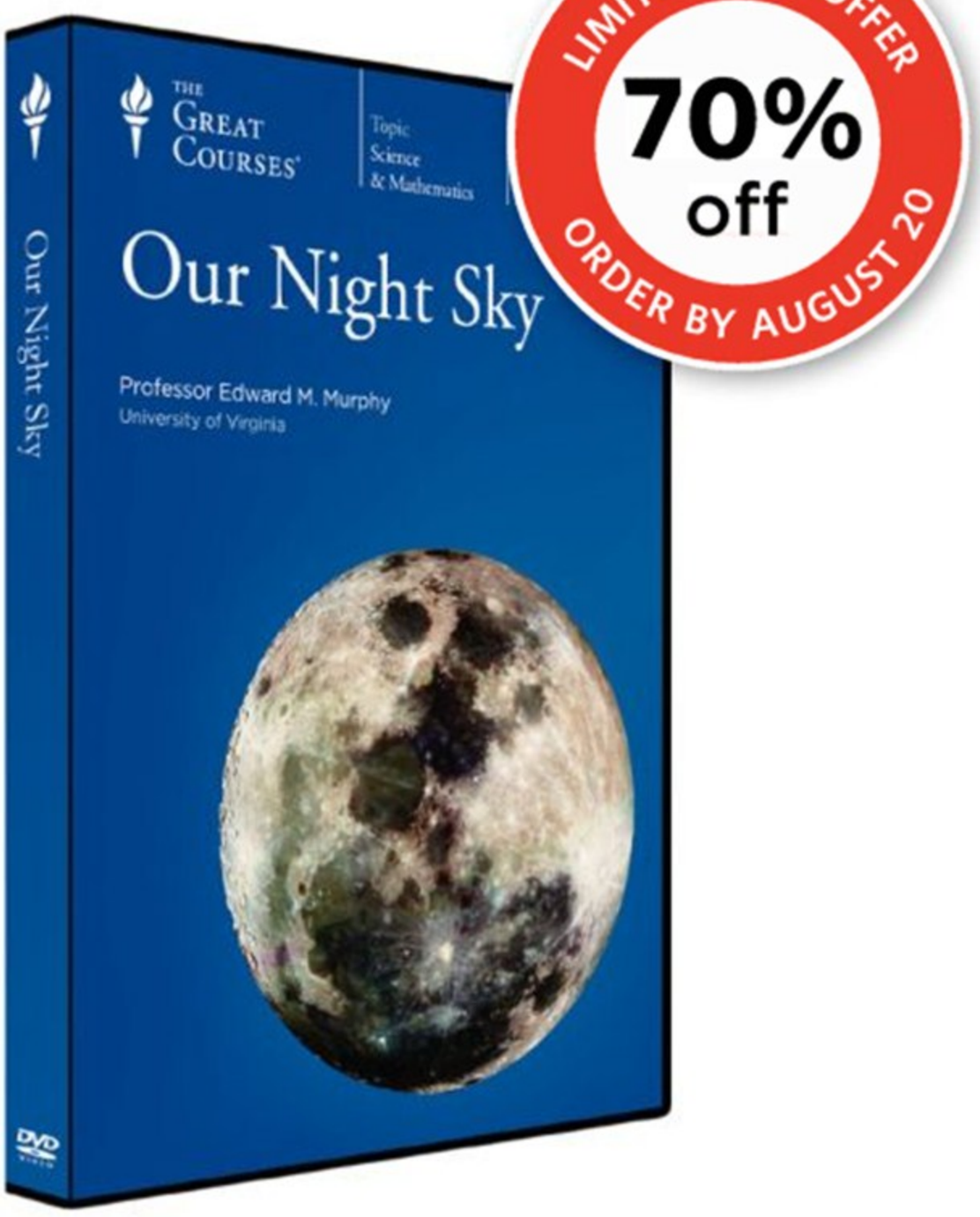
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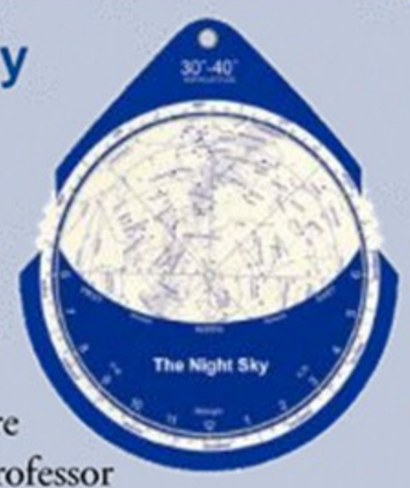
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Taming the Wild

Animals also have tamed humans. Animals have developed a trait of telling humans what to do. Cattle bellow when they want food or water. We humans answer their call. Has any research been done to determine how this trait developed?

- If this trait of animals in distress calling for help occurred in the wild, it would be an invitation for predators.

DAVID J. AMELING
Newbury Park, California

So people domesticate the fox and then sell it to be slaughtered for coats? That is so sad on so many levels. Russia, please stop the experiment and allow the remaining tame animals to be sold as the pets you created. That would make more money for the lab than selling them for pelts. Use the money to neuter and microchip the remaining foxes and close the facilities. We domesticated dogs, and now we kill millions of strays every year in the United States alone. Please don't add a new creature to the list.

LUCY JOHNSON
Dunkirk, New York

Dog owners have a survival advantage? What a joke. Dogs can spread disease to their owners, bite their owners, and even cause the owners to die when the person tries to rescue the dumb beast from a burning house or frigid river. It's not uncommon for a person to excuse themselves from the gene pool when they die trying to save their dog.

SAM FOSTER
Denver, Colorado

I am both a dog lover and a cat lover. I believe felines came to be domesticated for much the same reason as canines. It seems logical that as humans began to cultivate and store grain, cats would have been helpful as rodent control and thus allowed to hang around long enough for us to realize other desirable attributes, such as beauty, soft fur, and purring.

BARBARA DANLEY
Columbia, Missouri

I can't imagine that too many people would consider a fox the perfect pet until animal researchers design a means of eliminating the canid's musk. Ever since foxes infiltrated our suburban neighborhood, their presence has been instantly detectable from blocks away, thanks to their telltale pungent stench—every bit as strong as a colony of skunks'.

JOE McELWEE
Drexel Hill, Pennsylvania

Corrections

MARCH 2011: POLLINATORS The bee on pages 116-117 was misidentified. Its scientific name is *Augochloropsis metallica.*

SUPPLEMENT: THE FACE OF SEVEN BILLION
The world's median age is 28. This was incorrectly expressed on the poster as "the world's largest age bracket is 28."

FEEDBACK *This graphic summarizes the most common opinions found in your letters about our "Taming the Wild" story. The type is scaled by number of responses. Large phrases were the most common.*



EMAIL ngsforum@ngm.com **TWITTER** @NatGeoSociety **WRITE** National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Include name, address, and daytime telephone. Letters may be edited for clarity and length.

PROJECT HOPE
FOUNDED IN 1958

Project HOPE is committed to bringing sustainable healthcare to the poorest regions of the world. Since 1958, it has provided nearly $2 billion in medical aid and has helped train more than two million health workers.

Addressing diabetes worldwide since 1998 with programs in China and Mexico, Project HOPE is now focusing on diabetes education and treatment in India. For more information, please visit www.projecthope.org.



Rush hour in Old Delhi. In developing countries, those most frequently affected by diabetes are in the middle, productive years of their lives, aged between 35 and 64.

BD
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Partners in diabetes education

Diabetes, a manageable condition in many circumstances, is growing at an alarming rate worldwide. It is estimated today that 284 million people live with diabetes. In India alone, 51 million people have diabetes, and that number could reach 87 million by 2030.[1]

Project HOPE and BD are collaborating with other industry partners to implement the India Diabetes Educator Project, focused on training Allied Healthcare Professionals as Diabetes Educators. The goal of the project is to educate 3,000 nurses, dieticians and nutritionists over a three-year period on diabetes treatment. The program, recognized by the International Diabetes Federation, will help the Educators empower diabetes patients in self-care, leading to better health outcomes.

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[1] International Diabetes Federation, *2010 Diabetes Atlas*, [2] *FORTUNE®*, March 2011, [3] *Ethisphere™ Magazine*, April 2011

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LETTERS

I was gratified to see "Taming the Wild" include yaks among the domesticated species. Many people think that all yaks are wild. The wild yak is rarely found below 10,000 feet and is limited to a few remote regions of eastern Asia. By comparison, the 12 to 14 million domestic yaks can be found in a remarkable range of environments from Tibet to Texas and at latitudes from Sweden to New Zealand. Perhaps researchers trying to isolate the domestication gene should consider yaks, since it does not sound as if breeding stocks of domestic foxes will become widely available—or affordable—anytime soon. And when they do isolate the gene, what next? Piebald lions? Short-tailed tigers? Floppy-eared bears? Oh, my!

DIANNE B. LATONA
Everson, Washington

Why anyone would seek to evolve a "perfect pet" I do not know, because that has already been done. It's called the dachshund.

ROBERT L. OWENS
Cole Camp, Missouri

Age of Man

I was very intrigued by the chart of contributing factors (population, affluence, and technology) to the human impact on our planet, and I found the accompanying mathematical formula, $I = P \times A \times T$, to be clever if not discouraging. However, I would like to propose a fourth factor, education—and use it as a divisor in the formula to mitigate the effect of the multipliers. Neither affluence nor technology should be inherently damaging on a large scale. I believe that their lasting effects have more to do with how we use these resources. And as for population, that too can be mitigated with a good dose of education.

RICK WHITSON
Salt Lake City, Utah

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I agree with the IPAT formula, only I found it ironic to see bicycles illustrated in the PAT box graphic. Flying machines, weapons, computers, and ships definitely belong. The bicycle, however, is arguably the best mode of transportation mankind has. It is in a position to lessen human impact, if only it would be used by more of the world's population. This includes factors such as environment, health benefits, and efficiency of transport.

WILLIAM STELTER
Tahoe City, California

While technological growth can help us consume more and introduce more new pollutants, it can also ameliorate the effects of increasing population and consumption. The development of substitutes for chlorofluorocarbons allowed us to maintain high levels of growth while reducing our impact on ozone depletion. With our population approaching seven billion, technology may be our only option for sustainability.

KEMI GEORGE
Williamsburg, Virginia

Our impact on our environment will not be mitigated until we devise an economy that does not depend on constant increases in consumption and production. This is a tall order, but even total population stability will not work without it.

AL ROGERS
Duryea, Pennsylvania

I don't like the coined term "anthropocene" in your article. Since all of the large number of fertile people today were born from fertile women, I think the word "archocene" (from the Greek *archos,* meaning "master") is far more appropriate. The other is far too male—too androcentric! Gender-specific terms that are all-inclusive are antiquated.

JENNIFER MASON
Tallahassee, Florida

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*WKH Data 2010. Survey of orthopedic surgeons.
**Use as directed for minor arthritis pain.
‡Comparison to Extra Strength Tylenol based on minimum label dosing for 24 hours.
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BAYER

I disagree with those who say we can't pay for older people's pensions. All we need to do is change policies in four areas:

1 Extend pension eligibility age gradually.

2 Move away from income and toward consumption taxes, so that everyone contributes.

3 Compel everyone to save for retirement.

4 Develop postretirement, part-time work arrangements.

It is false logic to propose having more babies in order to pay for retirement pensions. What happens when those babies get old?

GORDON PAYNE
South Fremantle, Australia

History: Peace Corps Rising

Your article about the fluctuations of volunteer numbers from 1961 to recently was great, and as a current volunteer, I appreciate the publicity. Yet I had a problem with the photo showing the vintage fire-starting kit. Without reading the caption, I would have thought that the tools belonged to a volunteer in the 1960s. Instead they are from a 2005-07 service. It seems that Americans are often given the idea that Peace Corps volunteers venture to the deepest corners of the world to show people how a wheel and axle work. The tools in the photo send an incorrect message of the status of the Third World. Sure, at the moment I am sitting in my mud hut listening to termites chomp away on my thatch roof. But I am also sending this email with my Internet-accessible cell phone. The whole world is advancing, not just the First World.

CHUCK CASCIO
Petauke, Zambia

Before seeing the Peace Corps increase volunteer numbers, I'd like to see it decide its direction and future. Is it about making friends for America? About sustainability? About helping people realize their dreams? Or is it merely more government public relations? I volunteered with Habitat for Humanity International (HFHI), working in Africa until 2001. A year later I was in eastern Europe with the Peace Corps. I can only compare these organizations in the administrative and geographic areas I experienced, differences in volunteer preparedness (emotional as well as training), objective outcomes, volunteer satisfaction and dedication, and leadership. My eight years with the HFHI changed me forever. Peace Corps was a regrettable use of taxpayer dollars.

EVELYN WARAWKA
Ketchikan, Alaska

NATIONAL GEOGRAPHIC ON TV



THIS MONTH

Indestructibles

At age 25, skydiver Michael Holmes thought his life was over. “I ended up in a situation that no person would ever want to be in,” he recalls. He made the jump that almost killed him in 2006: His parachute malfunctioned, and his body plunged thousands of feet to the ground. Amazingly, Holmes lived. Find out how in *Indestructibles,* a new National Geographic show that goes across the globe to explain extraordinary cases of human survival.

Michael Holmes (above, at right) and his friend Jonathan King take to the air after Holmes's skydiving accident.



NATIONAL GEOGRAPHIC CHANNEL

How to Build a Volcano

Scientists engineer a house-size volcano, hoping to crack the code on one of nature’s most formidable forces.

Monster Fish

Zeb Hogan sets out on a quest to find and study the world’s largest freshwater fish.

For complete listings go to **natgeotv.com.**

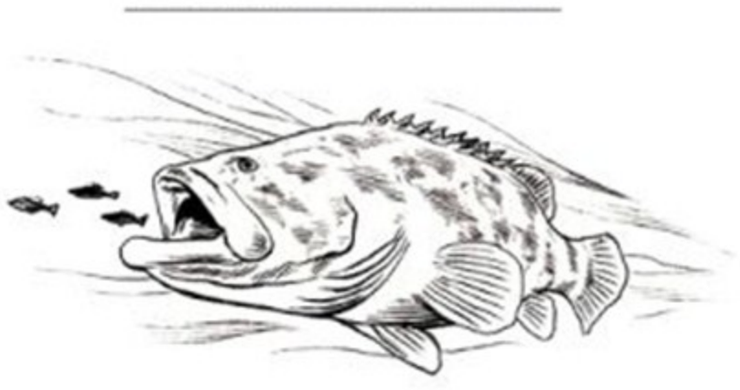
PHOTOS: JUERGEN REHBERG, STORY HOUSE PRODUCTIONS (TOP); NICK DE PENCIER, TWISTER FILMS

Founded in 1888, the National Geographic Society has supported more than 9,000 explorations and research projects, adding to our knowledge of earth, sea, and sky.



Instant Snow Goggles At some 17,000 feet up in Nepal's Hongu Valley, geographer Alton Byers and his team explored potential threats posed by new, unstable glacial lakes to villages downstream. They averted a more immediate threat—of snow blindness—when a local porter forgot his goggles on the Himalayan expedition. The solution? Duct tape, string, and a strategic slit (above). When Byers asked the porter how he was faring, he replied, "Fine, but I can't see my feet."

FIELD NOTES



SPEED FREAK When fish feed, the process is too fast to see with the naked eye, but biologist **Steve Huskey** gets help from a high-speed camera. Eating can take just 30 milliseconds for many fish, he notes. Goliath groupers, the focus of his studies, suck in water—and prey—at 50-plus miles an hour.



SHIP SEARCHER Two and a half centuries after the British warship H.M.S. *Swift* sank off Argentina's Patagonian coast, a team led by underwater archaeologist **Dolores Elkin** has confirmed that a skeleton in the wreck was a British marine. The evidence: traces of red wool from a long-gone uniform.



COBRA CHASER In an Indian rain forest, conservation scientist **Matt Goode** implanted radio tags in five king cobras and observed courtship, combat, and cannibalism —sometimes in quick succession. After a failed mating attempt, he reports, one subject "killed, swallowed, and regurgitated" a female.

PHOTO: ALTON BYERS, MOUNTAIN INSTITUTE. ART: JOE MCKENDRY

VISIONS

United States
At a Maui aquarium a Hawaiian green turtle makes a guest appearance. Members of this threatened species are unique among sea turtles for their herbivorous diet, thought to imbue their fat with a greenish hue.

PHOTO: JOSE CARDONA





Canada
Fluttering wings leave lacy trails as moths beat their way to a floodlight on a rural Ontario lawn. The midsummer night's exposure, held for 20 seconds, captured some of the hundreds of insects engaged in a nocturnal swarm.

PHOTO: STEVE IRVINE



Peru
Stone walls on Isla Guañape Norte prevent precious bird droppings, called guano, from falling into the Pacific. Coveted as fertilizer, the dung must be reaped by hand. Here a worker returns sifted-out feathers and bones.

PHOTO: TOMAS MUNITA

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This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot.*



EDITORS' CHOICE **Serena Amaduzzi** Rome, Italy

Walking around Havana, Cuba, after a thunderstorm, Amaduzzi, 23, stopped to watch two men fixing a broken-down car. "I saw a cute little face inside it, staring at me, and I smiled," she says. When the child's eyes smiled back, "it was like we'd shared a mute conversation."



READERS' CHOICE

Ellen Case
Baton Rouge, Louisiana

"This mosquito was trapped in a bead of cooking oil in a dish of water," says Case, 57. "I noticed it when I went to clean up the mess I'd made earlier," while working at home on a series of close-up shots. The refracted colors are from a plastic tablecloth beneath the dish.

Boys can be affected by HPV disease too.

GARDASIL HELPS PROTECT BOTH YOUR SON AND DAUGHTER.



When it comes to human papillomavirus (HPV), females are only half the equation. There are 30 to 40 types of HPV that will affect an estimated 75% to 80% of males and females in their lifetime. For most, HPV clears on its own. But, for others who don't clear certain types, HPV could cause cervical cancer in females and other types of HPV could cause genital warts in both males and females. And there's no way to predict who will or won't clear the virus.

GARDASIL is the only HPV vaccine that helps protect against 4 types of HPV. In girls and young women ages 9 to 26, GARDASIL helps protect against 2 types of HPV that cause about 75% of cervical cancer cases, and 2 more types that cause 90% of genital warts cases. In boys and young men ages 9 to 26, GARDASIL helps protect against 90% of genital warts cases.

GARDASIL may not fully protect everyone, nor will it protect against diseases caused by other HPV types or against diseases not caused by HPV. GARDASIL does not prevent all types of cervical cancer, so it's important for women to continue routine cervical cancer screenings.

GARDASIL does not treat cervical cancer or genital warts. GARDASIL is given as 3 injections over 6 months.

GARDASIL®

[Human Papillomavirus Quadrivalent (Types 6, 11, 16, and 18) Vaccine, Recombinant]

gardasil.com **1-800-GARDASIL**

IMPORTANT SAFETY INFORMATION

Anyone who is allergic to the ingredients of GARDASIL, including those severely allergic to yeast, should not receive the vaccine. GARDASIL is not for women who are pregnant.

The side effects include pain, swelling, itching, bruising, and redness at the injection site, headache, fever, nausea, dizziness, vomiting, and fainting. Fainting can happen after getting GARDASIL. Sometimes people who faint can fall and hurt themselves. For this reason, your child's health care professional may ask your child to sit or lie down for 15 minutes after he or she gets GARDASIL. Some people who faint might shake or become stiff. This may require evaluation or treatment by your child's health care professional.

Only a doctor or health care professional can decide if GARDASIL is right for your child.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088. Please read the Patient Information on the next page and discuss it with your child's doctor or health care professional.

3 to complete

MAKE SURE YOU GET ALL 3 DOSES
SO THAT YOU GET THE BEST PROTECTION.

Help your son or daughter be one less person affected by HPV disease.

Talk to your child's doctor about GARDASIL today.

Having trouble paying for your Merck medicine?
Merck may be able to help. Visit merck.com/merckhelps.

HPAP-1000854-0004-05/11

USPPI 9883616

Patient Information about GARDASIL® (pronounced "gard-Ah-sill")

Generic name: [Human Papillomavirus Quadrivalent (Types 6, 11, 16, and 18) Vaccine, Recombinant]

Read this information with care before getting GARDASIL[1]. You (the person getting GARDASIL) will need 3 doses of the vaccine. It is important to read this leaflet when you get each dose. This leaflet does not take the place of talking with your health care provider about GARDASIL.

What is GARDASIL?
GARDASIL is a vaccine (injection/shot) that is used for girls and women 9 through 26 years of age to help protect against the following diseases caused by Human Papillomavirus (HPV):

- Cervical cancer
- Vulvar and vaginal cancers
- Anal cancer
- Genital warts
- Precancerous cervical, vaginal, vulvar, and anal lesions

GARDASIL is used for boys and men 9 through 26 years of age to help protect against the following diseases caused by HPV:

- Anal cancer
- Genital warts
- Precancerous anal lesions
 - The diseases listed above have many causes, and GARDASIL only protects against diseases caused by certain kinds of HPV (called Type 6, Type 11, Type 16, and Type 18). Most of the time, these 4 types of HPV are responsible for the diseases listed above.
 - GARDASIL cannot protect you from a disease that is caused by other types of HPV, other viruses, or bacteria.
 - GARDASIL does not treat HPV infection.
 - You cannot get HPV or any of the above diseases from GARDASIL.

What important information about GARDASIL should I know?

- You should continue to get routine cervical cancer screening.
- GARDASIL may not fully protect everyone who gets the vaccine.
- GARDASIL will not protect against HPV types that you already have.

Who should not get GARDASIL?
You should not get GARDASIL if you have, or have had:

- an allergic reaction after getting a dose of GARDASIL.
- a severe allergic reaction to yeast, amorphous aluminum hydroxyphosphate sulfate, polysorbate 80.

What should I tell my health care provider before getting GARDASIL?
Tell your health care provider if you:

- are pregnant or planning to get pregnant. GARDASIL is not recommended for use in pregnant women.
- have immune problems, like HIV infection, cancer, or you take medicines that affect your immune system.
- have a fever over 100°F (37.8°C).
- had an allergic reaction to another dose of GARDASIL.
- take any medicines, even those you can buy over the counter.

Your health care provider will help decide if you should get the vaccine.

How is GARDASIL given?
GARDASIL is a shot that is usually given in the arm muscle. You will need 3 shots given on the following schedule:

- Dose 1: at a date you and your health care provider choose.
- Dose 2: 2 months after Dose 1.
- Dose 3: 6 months after Dose 1.

Fainting can happen after getting GARDASIL. Sometimes people who faint can fall and hurt themselves. For this reason, your health care provider may ask you to sit or lie down for 15 minutes after you get GARDASIL. Some people who faint might shake or become stiff. This may require evaluation or treatment by your health care provider.

Make sure that you get all 3 doses on time so that you get the best protection. If you miss a dose, talk to your health care provider.

Can other vaccines and medications be given at the same time as GARDASIL?
GARDASIL can be given at the same time as RECOMBIVAX HB®[1] [hepatitis B vaccine (recombinant)] or Menactra [Meningococcal (Groups A, C, Y and W-135) Polysaccharide Diphtheria Toxoid Conjugate Vaccine] and Adacel [Tetanus Toxoid, Reduced Diphtheria Toxoid and Acellular Pertussis Vaccine Adsorbed (Tdap)].

What are the possible side effects of GARDASIL?
The most common side effects with GARDASIL are:

- pain, swelling, itching, bruising, and redness at the injection site
- headache
- fever
- nausea
- dizziness
- vomiting
- fainting

There was no increase in side effects when GARDASIL was given at the same time as RECOMBIVAX HB [hepatitis B vaccine (recombinant)].

There was more injection-site swelling at the injection site for GARDASIL when GARDASIL was given at the same time as Menactra [Meningococcal (Groups A, C, Y and W-135) Polysaccharide Diphtheria Toxoid Conjugate Vaccine] and Adacel [Tetanus Toxoid, Reduced Diphtheria Toxoid and Acellular Pertussis Vaccine Adsorbed (Tdap)].

Tell your health care provider if you have any of the following problems because these may be signs of an allergic reaction:

- difficulty breathing
- wheezing (bronchospasm)
- hives
- rash

Tell your health care provider if you have:

- swollen glands (neck, armpit, or groin)
- joint pain
- unusual tiredness, weakness, or confusion
- chills
- generally feeling unwell
- leg pain
- shortness of breath
- chest pain
- aching muscles
- muscle weakness
- seizure
- bad stomach ache
- bleeding or bruising more easily than normal
- skin infection

Contact your health care provider right away if you get any symptoms that concern you, even several months after getting the vaccine.

For a more complete list of side effects, ask your health care provider.

What are the ingredients in GARDASIL?
The ingredients are proteins of HPV Types 6, 11, 16, and 18, amorphous aluminum hydroxyphosphate sulfate, yeast protein, sodium chloride, L-histidine, polysorbate 80, sodium borate, and water for injection.

This leaflet is a summary of information about GARDASIL. If you would like more information, please talk to your health care provider or visit www.gardasil.com.

Manufactured and Distributed by: Merck Sharp & Dohme Corp., a subsidiary of Merck & Co., Inc.
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Issued April 2011

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HPAP-1000854-0004-05/11



Francisco Little Beijing, China

"I don't think these snakes are poisonous, but the crowds are impressed anyway," says Little, 46, a South African who works as a media consultant in Beijing. The snake-handling show in which this girl performed was part of Chinese New Year entertainment at Beijing's Ditan Park.



Rick Wianecki
Los Alamitos, California

While on vacation in Thailand, "we wanted to step away from the busy city streets of Bangkok," says Wianecki, 56, an attorney. The reclining Buddha at the Wat Pho temple "was such a nice surprise to find. Immediately you are overwhelmed by his size."

Here, you can lose a day and then find yourself.



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Abu Dhabi



At a beach in Sydney, Australia, two girls frolic in a wave's effervescent wake.

World Beneath the Waves People do beautiful things in the water. They become braver and calmer, more fluid and playful. The freedom of buoyancy allows us to act as we truly are.

I grew up near the ocean in Australia, but I didn't appreciate our ancestral ties to it until I'd spent years living abroad. When I returned, I noticed how people here are drawn to the beaches. The pull is shared—a human equalizer. When you see swimmers in the ocean together, you see them react intuitively to the tide's push and pull.

I like the clarity of salt water. In the past dozen years my technique and equipment have stayed simple: a deep breath, a small camera, and transparency film, for its dense blacks and saturation. Despite new technologies, the magic of the darkroom still fascinates me.

On hot days I hang out where the waves are forming. Just before they break, I dive to the bottom. A flash of sunlight penetrates the curl and the churn, illuminating the swimmers above. They look like actors dancing or flying on an underwater stage. I take one picture, surface, breathe, and repeat. Shooting 36 frames might take a day.

We love the sea, yet we pollute it. As a mother, I agonize over what my children will inherit. But I'm also optimistic. If we can notice natural beauty, we might learn how to preserve it. —*Narelle Autio*

Narelle Autio is a photographer based in Adelaide, Australia. Her images of the country's coastal life are exhibited internationally.











As big waves buffet the eastern Australian coast, a father clings to his son. I get pounded in the same surf as the swimmers, so I never know exactly what my shots will show until I develop them.

Swimmers paddle in the clear surf of Sydney's Freshwater Beach. For many of us the water is a playground. But to me these images show something else: our shared humanity when we're immersed.

On the sandy floor of a popular Sydney beach, a girl floats in a prone position, her life held in a breath of air. Despite its many mysteries and dangers, the ocean exerts an elemental pull that draws us back.

At Bondi Beach near Sydney, a young woman dives to safety as a vast wave rolls overhead. It's always a nice surprise to me when the light, the wave, and the swimmer come together perfectly in one frame.

NOW

SKYCAST

Overhead this month in parts of the world

July 1
Partial solar eclipse



Jurassic Mother Lode

Pterosaurs died out with the dinosaurs, leaving more mysteries than fossils. Now paleontologists who study the flying vertebrates are hitting pay dirt. In 2009 a transitional form in pterosaur evolution, *Darwinopterus,* was found in China. Then the site yielded a 160-million-year-old fossil of one with an egg (above).

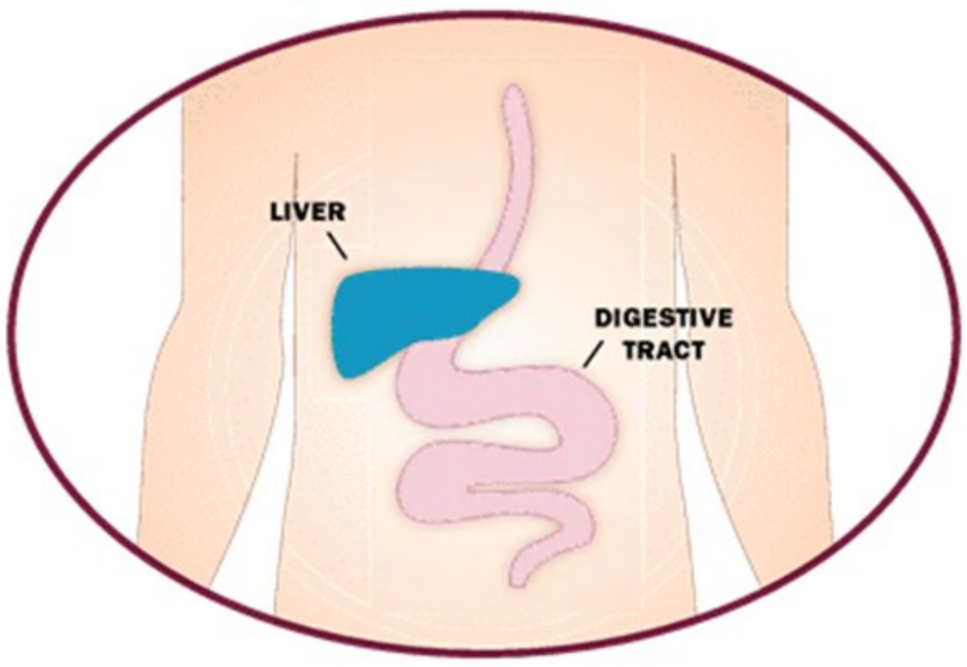
The University of Leicester's David Unwin and colleagues say the latter find bolsters a hypothesis that pterosaurs were sexually distinct: Females had wider hips, and only males had head crests. Other experts agree, but Kevin Padian of the University of California, Berkeley argues that we don't yet know enough about pterosaur maturation to say whether age or gender accounts for physical differences among fossils. More scrutiny may resolve that flap—and help decipher other abiding pterosaur enigmas. *—Jeremy Berlin*

This fossil from China's Liaoning Province reveals a pterosaur—about the size of a small falcon—with an egg (circle).

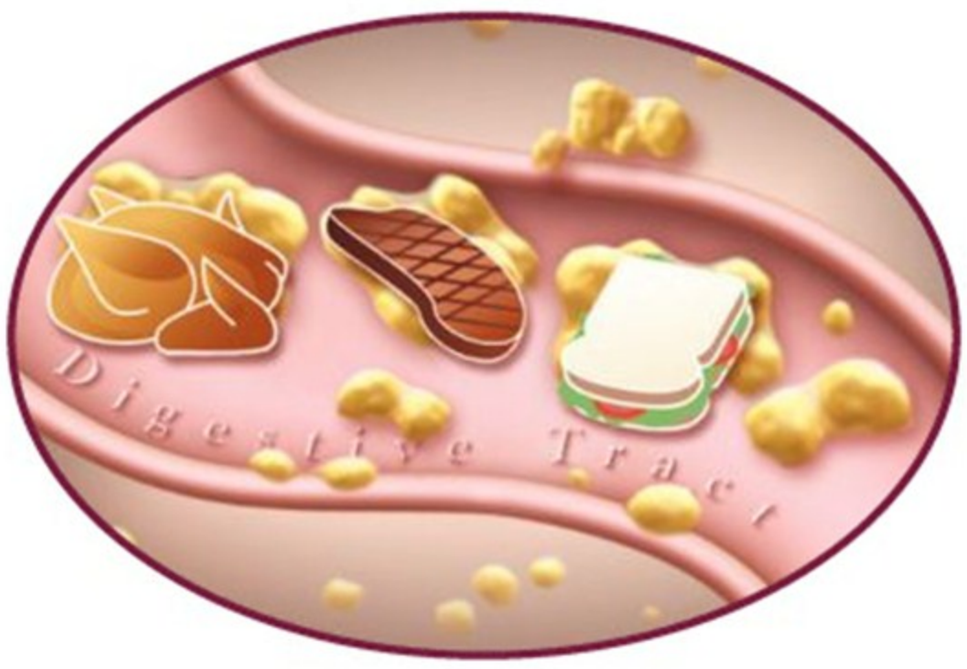
PHOTO: DING MING, ZHEJIANG MUSEUM OF NATURAL HISTORY

If you diet and take a statin, ZETIA can help lower LDL (bad) cholesterol even more.

Statins, a good option, work mainly with the liver. **ZETIA works in the digestive tract,** as do some other cholesterol-lowering medicines.



Cholesterol from food is absorbed when it enters the digestive tract.



ZETIA is unique in the way it helps block the absorption of cholesterol that comes from food. **Unlike some statins, ZETIA has not been shown to prevent heart disease or heart attacks.**



A healthy diet and exercise are important, but sometimes they're not enough to get your cholesterol where it needs to be. If you're also taking a statin, ZETIA can help lower your LDL (bad) cholesterol even further. In a clinical study, people who added ZETIA to their statin medication reduced their bad cholesterol on average by an additional 25% compared with 4% in people who added a placebo (a pill with no medication). Individual results vary.

Important Risk Information About ZETIA: ZETIA is a prescription medicine and should not be taken by people who are allergic to any of its ingredients. ZETIA can be taken alone or with a statin. Statins should not be taken by women who are nursing or pregnant or who may become pregnant, or by anyone with liver problems. If you have ever had liver problems or are pregnant or nursing, your doctor will decide if ZETIA alone is right for you. Your doctor may do blood tests to check your liver before you start taking ZETIA with a statin and during treatment.

Unexplained muscle pain or weakness could be a sign of a rare but serious side effect and should be reported to your doctor right away. In clinical studies, patients reported few side effects while taking ZETIA. These included diarrhea, joint pains, and tiredness.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please read the more detailed information about ZETIA on the adjacent page.

For more information, call **1-800-98-ZETIA** or visit **zetia.com**.

To learn about a free 30-day trial supply* offer for ZETIA, visit zetia.com.

*Not all patients are eligible. No purchase necessary. Restrictions apply. See Terms and Conditions.

Ask your doctor if adding ZETIA is right for you.

Zetia® (ezetimibe) Tablets

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ZETIA® (EZETIMIBE) TABLETS
PATIENT INFORMATION ABOUT *ZETIA* (zĕt´-ē-ă)

Generic name: ezetimibe (ĕ-zĕt´-ĕ-mīb)

Read this information carefully before you start taking ZETIA and each time you get more ZETIA. There may be new information. This information does not take the place of talking with your doctor about your medical condition or your treatment. If you have any questions about ZETIA, ask your doctor. Only your doctor can determine if ZETIA is right for you.

WHAT IS *ZETIA*?

ZETIA is a medicine used to lower levels of total cholesterol and LDL (bad) cholesterol in the blood. ZETIA is for patients who cannot control their cholesterol levels by diet and exercise alone. It can be used by itself or with other medicines to treat high cholesterol. You should stay on a cholesterol-lowering diet while taking this medicine.

ZETIA works to reduce the amount of cholesterol your body absorbs. ZETIA does not help you lose weight. ZETIA has not been shown to prevent heart disease or heart attacks.

For more information about cholesterol, see the "What should I know about high cholesterol?" section that follows.

WHO SHOULD NOT TAKE *ZETIA*?

- Do not take ZETIA if you are allergic to ezetimibe, the active ingredient in ZETIA, or to the inactive ingredients. For a list of inactive ingredients, see the "Inactive ingredients" section that follows.
- If you have active liver disease, do not take ZETIA while taking cholesterol-lowering medicines called statins.
- If you are pregnant or breast-feeding, do not take ZETIA while taking a statin.
- If you are a woman of childbearing age, you should use an effective method of birth control to prevent pregnancy while using ZETIA added to statin therapy.

ZETIA has not been studied in children under age 10.

WHAT SHOULD I TELL MY DOCTOR BEFORE AND WHILE TAKING *ZETIA*?

Tell your doctor about any prescription and non-prescription medicines you are taking or plan to take, including natural or herbal remedies.

Tell your doctor about all your medical conditions including allergies.

Tell your doctor if you:

- ever had liver problems. ZETIA may not be rightfor you.
- are pregnant or plan to become pregnant. Your doctor will discuss with you whether ZETIA is right for you.
- are breast-feeding. We do not know if ZETIA can pass to your baby through your milk. Your doctor will discuss with you whether ZETIA is right for you.
- experience unexplained muscle pain, tenderness, or weakness.

HOW SHOULD I TAKE *ZETIA*?

- Take ZETIA once a day, with or without food. It may be easier to remember to take your dose if you do it at the same time every day, such as with breakfast, dinner, or at bedtime. If you also take another medicine to reduce your cholesterol, ask your doctor if you can take them at the same time.
- If you forget to take ZETIA, take it as soon as you remember. However, do not take more than one dose of ZETIA a day.
- Continue to follow a cholesterol-lowering diet while taking ZETIA. Ask your doctor if you need diet information.
- Keep taking ZETIA unless your doctor tells you to stop. It is important that you keep taking ZETIA even if you do not feel sick.

See your doctor regularly to check your cholesterol level and to check for side effects. Your doctor may do blood tests to check your liver before you start taking ZETIA with a statin and during treatment.

WHAT ARE THE POSSIBLE SIDE EFFECTS OF *ZETIA*® (EZETIMIBE)?

In clinical studies patients reported few side effects while taking ZETIA. These included diarrhea, joint pains, and feeling tired.

Patients have experienced severe muscle problems while taking ZETIA, usually when ZETIA was added to a statin drug. If you experience unexplained muscle pain, tenderness, or weakness while taking ZETIA, contact your doctor immediately. You need to do this promptly, because on rare occasions, these muscle problems can be serious, with muscle breakdown resulting in kidney damage.

Additionally, the following side effects have been reported in general use: allergic reactions (which may require treatment right away) including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing, rash, and hives; raised red rash, sometimes with target-shaped lesions; joint pain; muscle aches; alterations in some laboratory blood tests; liver problems; stomach pain; inflammation of the pancreas; nausea; dizziness; tingling sensation; depression; headache; gallstones; inflammation of the gallbladder.

Tell your doctor if you are having these or any other medical problems while on ZETIA. For a complete list of side effects, ask your doctor or pharmacist.

WHAT SHOULD I KNOW ABOUT HIGH CHOLESTEROL?

Cholesterol is a type of fat found in your blood. Your total cholesterol is made up of LDL and HDL cholesterol.

LDL cholesterol is called "bad" cholesterol because it can build up in the wall of your arteries and form plaque. Over time, plaque build-up can cause a narrowing of the arteries. This narrowing can slow or block blood flow to your heart, brain, and other organs. High LDL cholesterol is a major cause of heart disease and one of the causes for stroke.

HDL cholesterol is called "good" cholesterol because it keeps the bad cholesterol from building up in the arteries.

Triglycerides also are fats found in your blood.

GENERAL INFORMATION ABOUT *ZETIA*

Medicines are sometimes prescribed for conditions that are not mentioned in patient information leaflets. Do not use ZETIA for a condition for which it was not prescribed. Do not give ZETIA to other people, even if they have the same condition you have. It may harm them.

This summarizes the most important information about ZETIA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about ZETIA that is written for health professionals.

Inactive ingredients:
Croscarmellose sodium, lactose monohydrate, magnesium stearate, microcrystalline cellulose, povidone, and sodium lauryl sulfate.

Issued July 2009
REV 21

29480885T

Zetia®
(ezetimibe) Tablets

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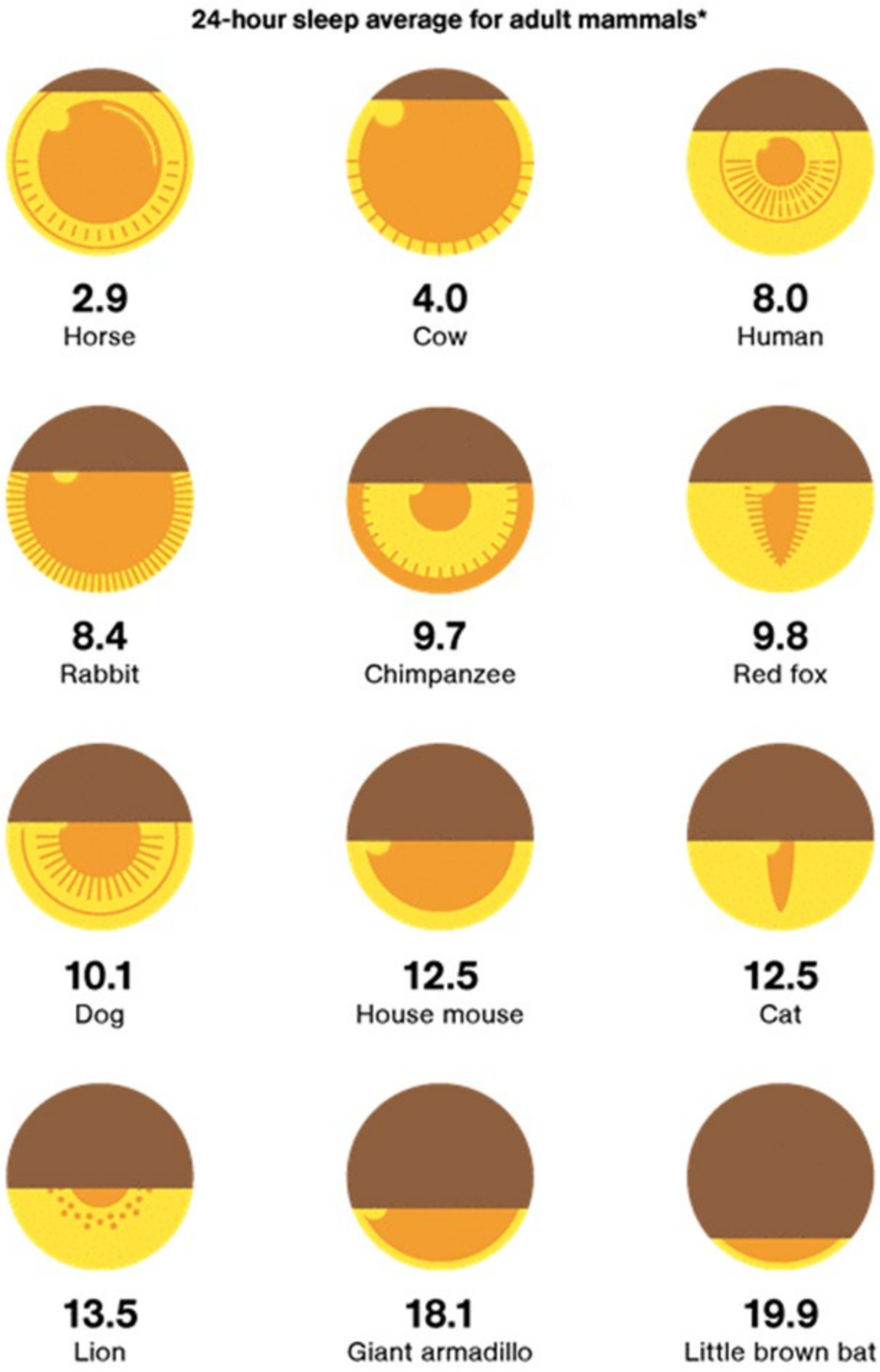
Available on the App Store

40 Winks?

Life is hard, and mammals need their z's to slog through it. But why does a chipmunk need about 15 hours of shut-eye a day, when a giraffe needs only 4.5? One answer, says UCLA sleep researcher Jerome Siegel, lies in the varied ways animals have adapted to be energy efficient and to stay safe.

Consider elephants, which nod off just three-plus hours a day. "To be so big, they have to eat most of the time," Siegel says. In contrast, it makes evolutionary sense for brown bats to conserve energy except during the few hours a night when their insect prey is out. A platypus also can feed less and slumber more (14 hours). Why? Maybe because just a little crustacean meal packs a huge caloric punch.

As for safety, those mammals that nap in hiding, like bats or rodents, tend to have longer, deeper snoozes than those on constant alert. Of course, a few beasts can slumber anytime, anywhere. Says Siegel, "Who's going to mess with a sleeping lion?" *—Jennifer S. Holland*





Giraffes sleep briefly and lightly—logical for animals that nap out in the open.

GRAPHIC: ÁLVARO VALIÑO. SOURCE: JEROME M. SIEGEL, UCLA
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Photograph by Michael Melford; inset photo of Michael Melford photographed by Elizabeth Nicole.

Aerial view of forest, Acadia National Park, Maine



MICHAEL MELFORD

NATIONAL GEOGRAPHIC PHOTOGRAPHER, ON

America's National Parks

"*Acadia National Park* has been very good to me. My first visit to a national park was just after graduation from high school, when I went to Acadia, driving all night and getting there in time for sunrise on top of Cadillac Mountain—the first place you can view the sun come up in the United States from October to March. I was definitely the first guy to see it the day I took this picture [above]. Acadia was also my first *National Geographic Traveler* assignment, which resulted in a cover story. Twelve years later, ironically, my very first assignment for *National Geographic* magazine was also in Acadia. Since then, I've done stories on Death Valley, Great Smoky Mountains, and Glacier National Parks for the magazine, as well as a cover story on the state of our national parks in 2006. I have traveled all over the world, and there's no park system anywhere like ours."

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In just ten years, U.S. fireworks revenue exploded.

1999
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2009
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Perceived threats to bird nests can trigger "angry" swoops, like this tern's on the U.K.'s Farne Islands.

Angry Bird Watch The popularity of the video game Angry Birds, in which feathered friends launch themselves at pigs that have stolen their eggs, may have some people wondering: Do birds get mad in the real world? Indeed they do—especially when their nests are threatened.

Golfers in the Great Plains of the United States regularly risk dive-bombing by Mississippi kites, medium-size hawks that often build their homes in trees near open areas and react aggressively when people approach. Even more common are attacks by mockingbirds. Cats, dogs, and humans walking near a mockingbird nest, usually in urban and suburban areas, can expect a close encounter with an angry parent and even a sharp peck.

The world champion angry bird, though, may well be the goshawk, a large raptor with needle-sharp talons that breeds in northern regions. The female of this species, when protecting her nest, may be the most dangerous bird on Earth to humans. Biologists working near their nests wear protective clothing to ward off bloody attacks. How nasty are goshawks? Attila the Hun decorated his battle helmet with the figure of one. *—Mel White*



MAKING WAY FOR EUROS Seventeen European Union countries have adopted the euro since its introduction in 1999, replacing such national currencies as Dutch guilders, French francs, and—as of January 1—Estonian krooni. What happens to all those retired coins? Some are waffled, like this kroon (left), then sold as scrap metal or reminted. But many coins are simply never exchanged, including 41 percent of francs and around 500 million euros' worth of guilders. Banks call that hoarding behavior, but nostalgia sounds nicer. *—Amanda Fiegl*

PHOTOS: PETE MELLA (TOP); REBECCA HALE, NGM STAFF
GRAPHIC: EBOY. SOURCE: AMERICAN PYROTECHNICS ASSOCIATION

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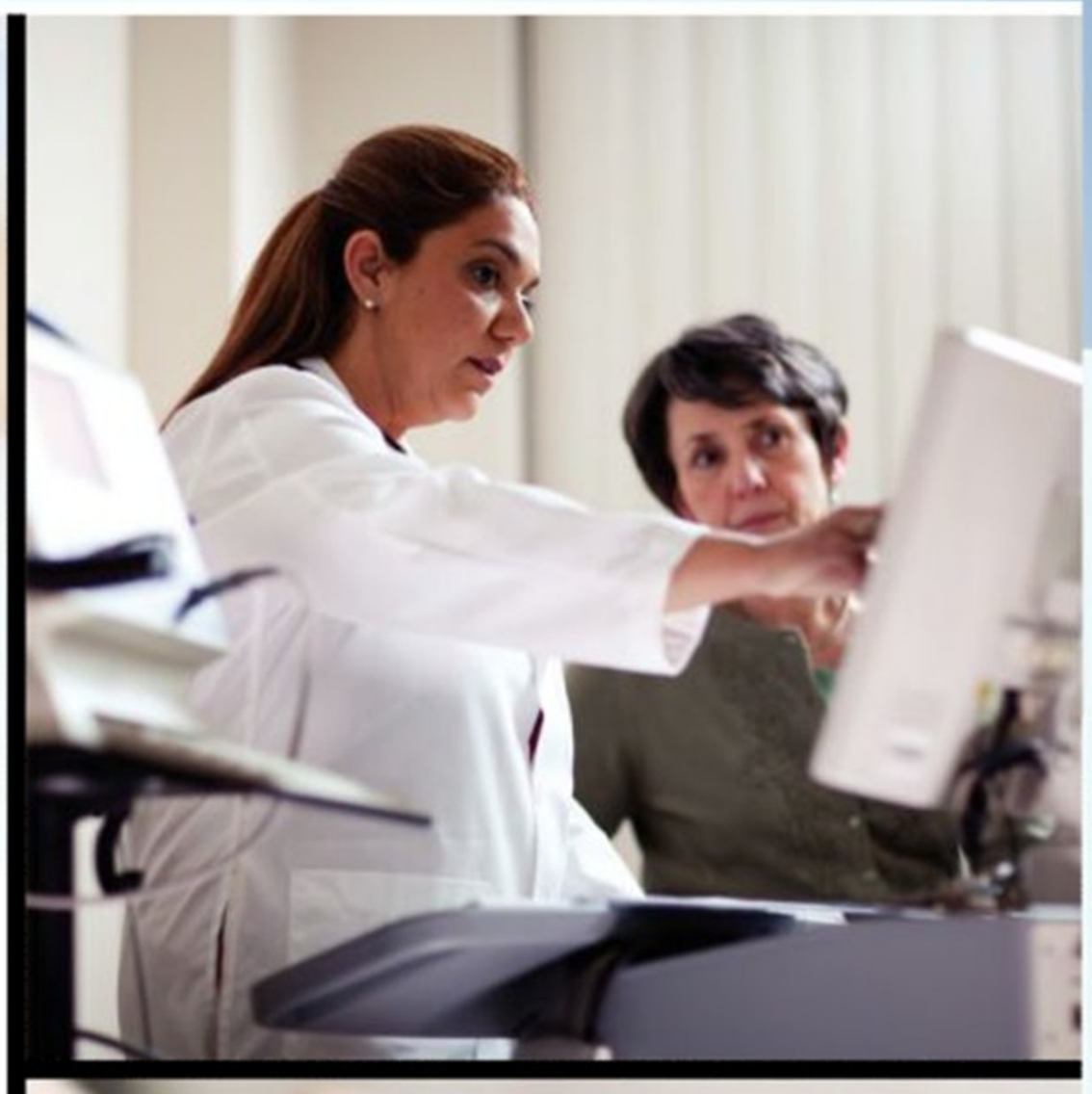
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and for more information about PRADAXA call 1-877-PRADAXA or visit pradaxa.com.

Boehringer Ingelheim

If you have an irregular heartbeat called *atrial fibrillation* *not caused by a heart valve problem* ask your doctor about **PRADAXA**.

- In a clinical trial, PRADAXA 150 mg **reduced stroke risk 35% more** than warfarin.
 Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.
- **No regular blood tests**

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem. With atrial fibrillation, part of the heart does not beat the way it should. This can cause blood clots to form, increasing your risk of a stroke. PRADAXA lowers the chance of blood clots forming in your body.

IMPORTANT SAFETY INFORMATION ABOUT *PRADAXA*

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it. **Your risk of bleeding with PRADAXA may be higher if you:** are 75 years old or older, have kidney problems, have stomach or intestine bleeding that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase your risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinners.

Call your doctor or seek immediate medical care if you have any of the following signs or symptoms of bleeding: any unexpected, severe, or uncontrollable bleeding; or bleeding that lasts a long time, unusual or unexpected bruising, coughing up or vomiting blood; or vomit that looks like coffee grounds, pink or brown urine; red or black stools (looks like tar), unexpected pain, swelling, or joint pain, headaches and feeling dizzy or weak.

It is important to tell your doctor about all medicines, vitamins and supplements you take. Some of your other medicines may affect the way PRADAXA works.

Take PRADAXA exactly as prescribed by your doctor. Don't stop taking PRADAXA without talking to your doctor as your risk of stroke may increase.

Tell your doctor if you are planning to have **any** surgery, or medical or dental procedure, because you may have to stop taking PRADAXA for a short time. PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda/medwatch or call 1-800-FDA-1088.

Please see more detailed Medication Guide on next page.

Reduce your risk of a stroke caused by a clot that starts in the heart.

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CAPSULES

PX88304CONSB

MEDICATION GUIDE

PRADAXA (pra dax' a)
(dabigatran etexilate mesylate)
capsules

Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

What is the most important information I should know about PRADAXA?

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
 - Are over 75 years old
 - Have kidney problems
 - Have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
 - Take other medicines that increase your risk of bleeding, including:
 - aspirin or aspirin containing products
 - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
 - warfarin sodium (Coumadin®, Jantoven®)
 - a medicine that contains heparin
 - clopidogrel (Plavix®)
 - prasugrel (Effient®)

 Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.
- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
 - You may bruise more easily
 - It may take longer for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:

- Unexpected bleeding or bleeding that lasts a long time, such as:
 - unusual bleeding from the gums
 - nose bleeds that happen often
 - menstrual bleeding or vaginal bleeding that is heavier than normal
- Bleeding that is severe or you cannot control
- Pink or brown urine
- Red or black stools (looks like tar)
- Bruises that happen without a known cause or get larger
- Cough up blood or blood clots
- Vomit blood or your vomit looks like "coffee grounds"
- Unexpected pain, swelling, or joint pain
- Headaches, feeling dizzy or weak

Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure. **See "What are the possible side effects of PRADAXA?" for more information about side effects.**

What is PRADAXA?

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

Who should not take PRADAXA?

Do not take PRADAXA if you:

- Currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- Have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

What should I tell my doctor before taking PRADAXA?

Before you take PRADAXA, tell your doctor if you:

- Have kidney problems
- Have ever had bleeding problems
- Have ever had stomach ulcers
- Have any other medical condition
- Are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- Are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See "**What is the most important information I should know about PRADAXA**?"

Especially tell your doctor if you take:

- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

How should I take PRADAXA?

- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See "What is the most important information I should know about PRADAXA?"
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor or the Poison Control Center right away.

What are the possible side effects of PRADAXA?

PRADAXA can cause serious side effects.

- See "What is the most important information I should know about PRADAXA?"
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
 - chest pain or chest tightness
 - swelling of your face or tongue
 - trouble breathing or wheezing
 - feeling dizzy or faint

Common side effects of PRADAXA include:

- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

How should I store PRADAXA?

- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 30 days. Safely throw away any unused PRADAXA after 30 days.
- Store PRADAXA in the original package to keep it dry. Keep the bottle tightly closed.

Keep PRADAXA and all medicines out of the reach of children.

General information about PRADAXA

Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. Do not use PRADAXA for a condition for which it was not prescribed. Do not give your PRADAXA to other people, even if they have the same symptoms. It may harm them.

This Medication Guide summarizes the most important information about PRADAXA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about PRADAXA that is written for health professionals.

For more information, go to www.PRADAXA.com or call 1-800-542-6257 or (TTY) 1-800-459-9906.

What are the ingredients in PRADAXA?

Active ingredient: dabigatran etexilate mesylate

Inactive ingredients: acacia, dimethicone, hypromellose, hydroxypropyl cellulose, talc, and tartaric acid. The capsule shell is composed of carrageenan, FD&C Blue No. 2, FD&C Yellow No. 6, hypromellose, potassium chloride, titanium dioxide, and black edible ink.

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Issued March 2011

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How to Feed a Growing Planet

Here's an uncomfortable math problem: By 2045 Earth's population will likely have swelled from seven to nine billion people. To fill all those stomachs—while accounting for shifting consumption patterns, climate change, and a finite amount of arable land and potable water—some experts say global food production will have to double. How can we make the numbers add up?

7 SEVEN BILLION

Julian Cribb, author of *The Coming Famine,* says higher yielding crop varieties and more efficient farming methods will be crucial. So will waste reduction. Cribb and other experts urge cities to reclaim nutrients and water from waste streams and preserve farmland. Poor countries, they say, can improve crop storage and packaging. And rich nations could cut back on resource-intensive foods like meat. In fact, wherever easy access to cheap food means people buy more than they consume, we could all start by shopping smarter—and cleaning our plates.

As Cribb notes, food security is increasingly a collective challenge. It's also a chance "to pull together on something we can all agree about, share, and enjoy." *—Amanda Fiegl*



1 Adjust Diets
Less meat can mean more food. Soybeans, for instance, provide up to 15 times more protein per acre than land set aside for meat production, according to the National Soybean Research Laboratory.



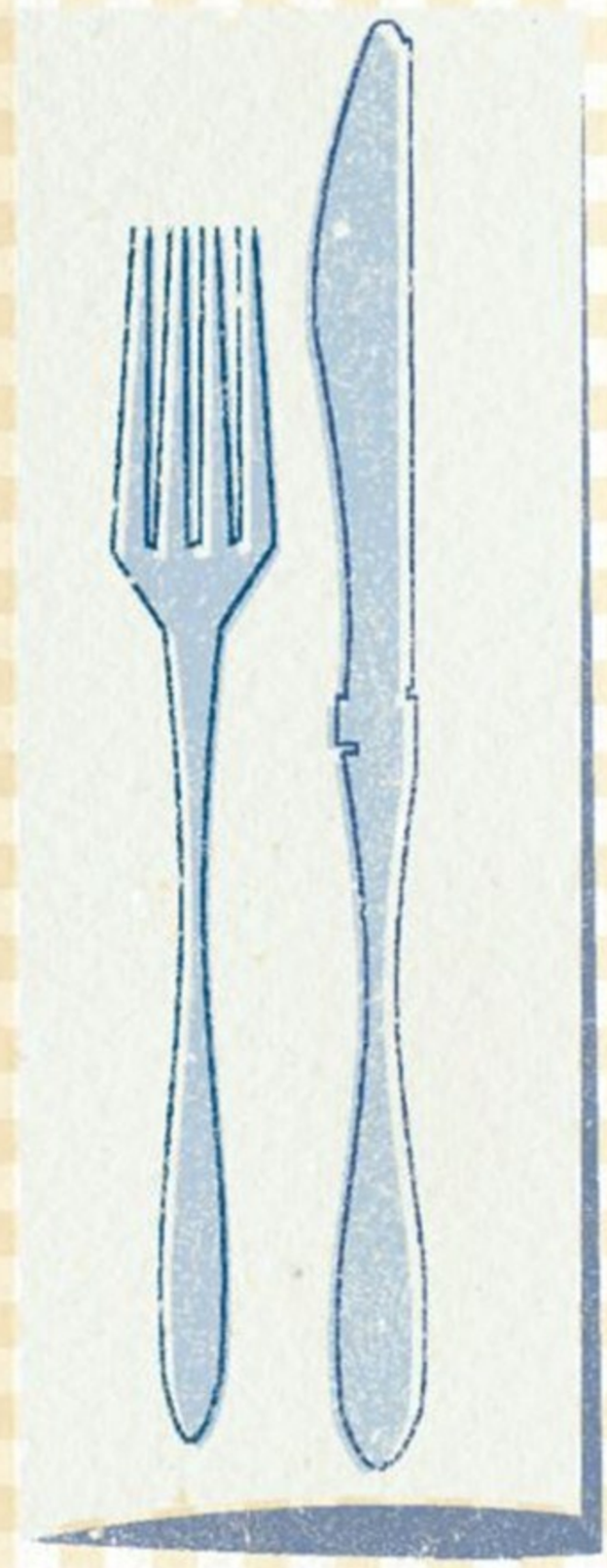
2 Increase Research
Global grain yields aren't increasing fast enough, and scientists warn that a fungus could imperil commercial wheat. Yet in recent decades, agricultural R & D has become less focused on productivity.



3 Reduce Waste
Up to half the world's harvest disappears "between field and fork," says the Stockholm International Water Institute. Waste, diversion to animal feed, and consumer behavior all play a role.

Waste not, want not

This meal shows the average amount of food purchased, and wasted, per person in the United States during the course of a year.*

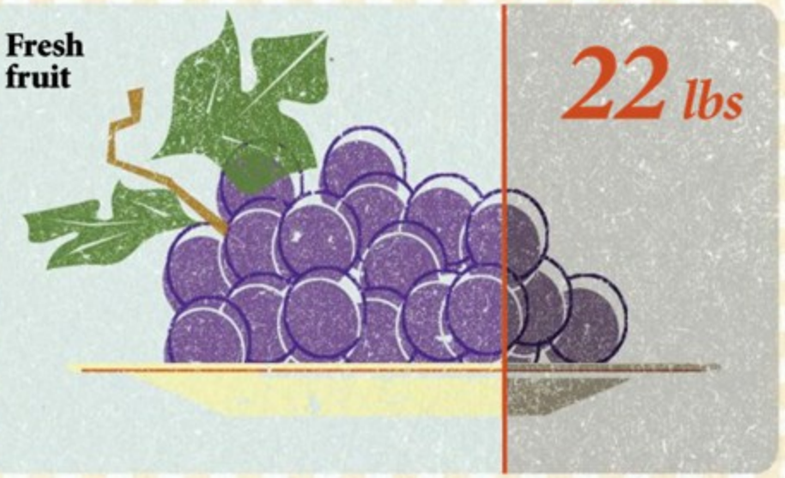


Purchased **77 lbs**

Wasted

Fresh fruit

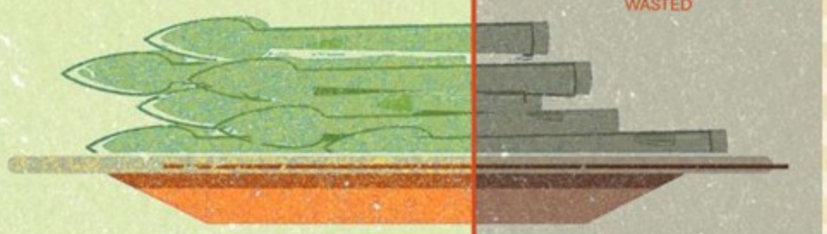
22 lbs



131 lbs

Fresh vegetables

39 lbs
WASTED



168 lbs

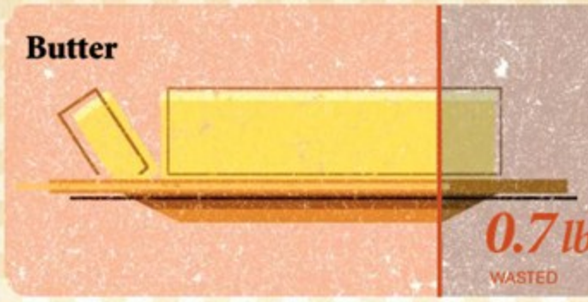


Milk

34 lbs
WASTED

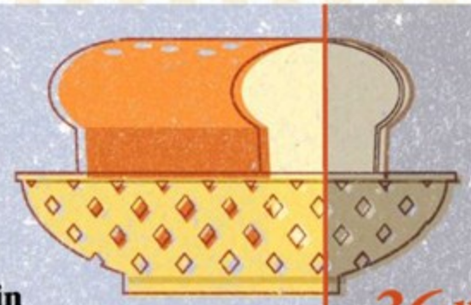
5 lbs

Butter



0.7 lb
WASTED

173 lbs

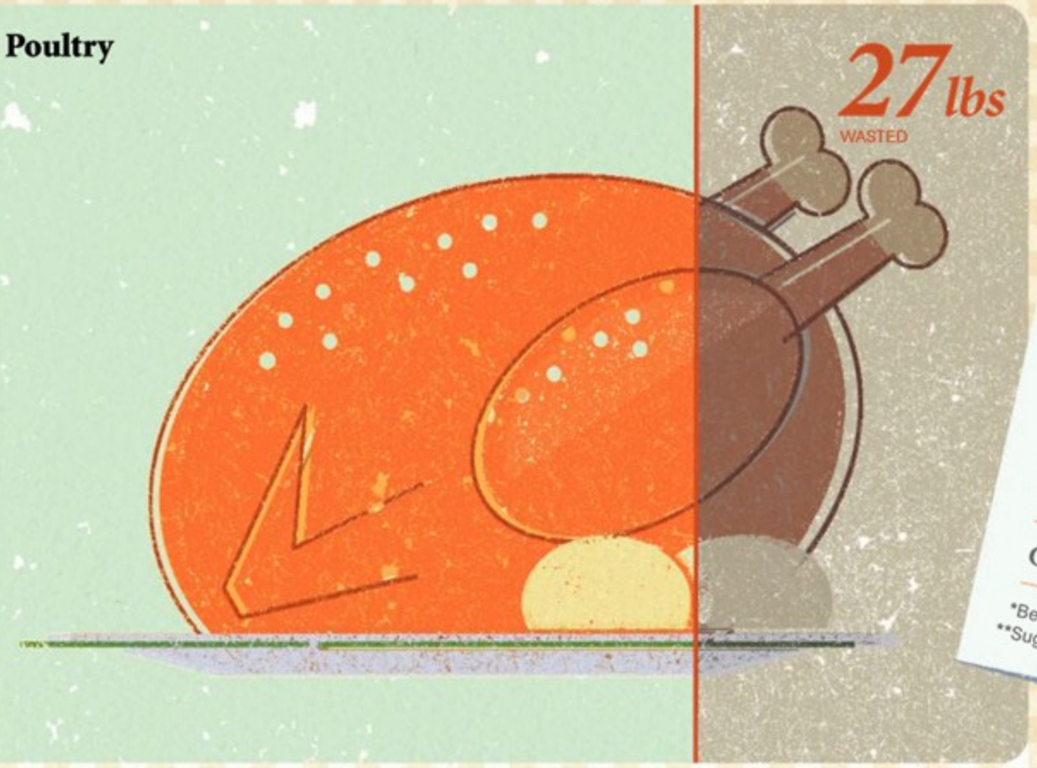


Grain products

36 lbs
WASTED

70 lbs

Poultry



27 lbs
WASTED

Other Wasted Foods

FOOD	PURCHASED / WASTED
Red meat*	103 lbs / 36 lbs
Fish and seafood	15 lbs / 4 lbs
Eggs	26 lbs / 4 lbs
Peanuts / tree nuts	9 lbs / 0.9 lb
Sweeteners**	121 lbs / 24 lbs
Cheese	28 lbs / 4 lbs

*Beef, pork, veal, and lamb
**Sugar, corn sweeteners, honey, and syrups

*2008, the latest year data is available. Amounts do not include nonedible food parts such as bones, peels, pits, and cores.

JOHN TOMANIO, NGM STAFF. ART: JOHN KLEBER. RESEARCH: MEGAN CASSIDY. SOURCES: HODAN WELLS, JEAN BUZBY, USDA

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60%

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Manatees in Hot Water

Sea cows are gentle creatures, with few natural predators. Yet the 5,000-plus manatees in Florida waters can't catch a break. They've long been the victims of watercraft, entanglements, and red tide, but now their deadliest foe is low temperatures. Over the past two winters, says the Florida Fish and Wildlife Conservation Commission, hypothermia and stress from cold weather—including the most frigid 12-day stretch in 70 years—have killed at least 400 of the endangered mammals.

Manatees are tubby but lack the insulating blubber of whales. In winter they once relied on warm springs; now they depend largely on the effluent discharged by power plants. Even some off-line plants, like this one in Palm Beach County (above), are required to heat the water to 61°F. But hot tubs can only do so much. More temperate winters would help keep the surrounding waters suitably warm—and manatee populations afloat. *—Gretchen Parker*

THE LIST

Accidental Archaeology

A man with a metal detector found Britain's biggest trove of Anglo-Saxon gold. Here are five cases in which amateur U.K. treasure hunters have turned up key artifacts.
—Malcolm Jack



1992
Hoxne Hoard
In Suffolk, Eric Lawes uncovered a $2.8-million collection of Roman gold and objects, such as this silver tigress.

2001 **Ringlemere Cup**
A plow crushed the gold Bronze Age chalice before Cliff Bradshaw found it in a Kent field.

2003 **Domitianus Coin**
Discovered in Oxfordshire by Brian Malin, one coin among 5,000 confirmed the existence of a "lost" Roman emperor.

2009 **Stirling Hoard**
Minutes into his first foray, David Booth found four gold Iron Age neck ornaments in a boggy Stirlingshire meadow.

2009 **Staffordshire Hoard**
Terry Herbert hit the $5.3-million jackpot: the largest collection of Anglo-Saxon booty ever discovered in the U.K.

PHOTOS: LANNIS WATERS, *PALM BEACH POST*/AP IMAGES (LEFT); TRUSTEES OF THE BRITISH MUSEUM

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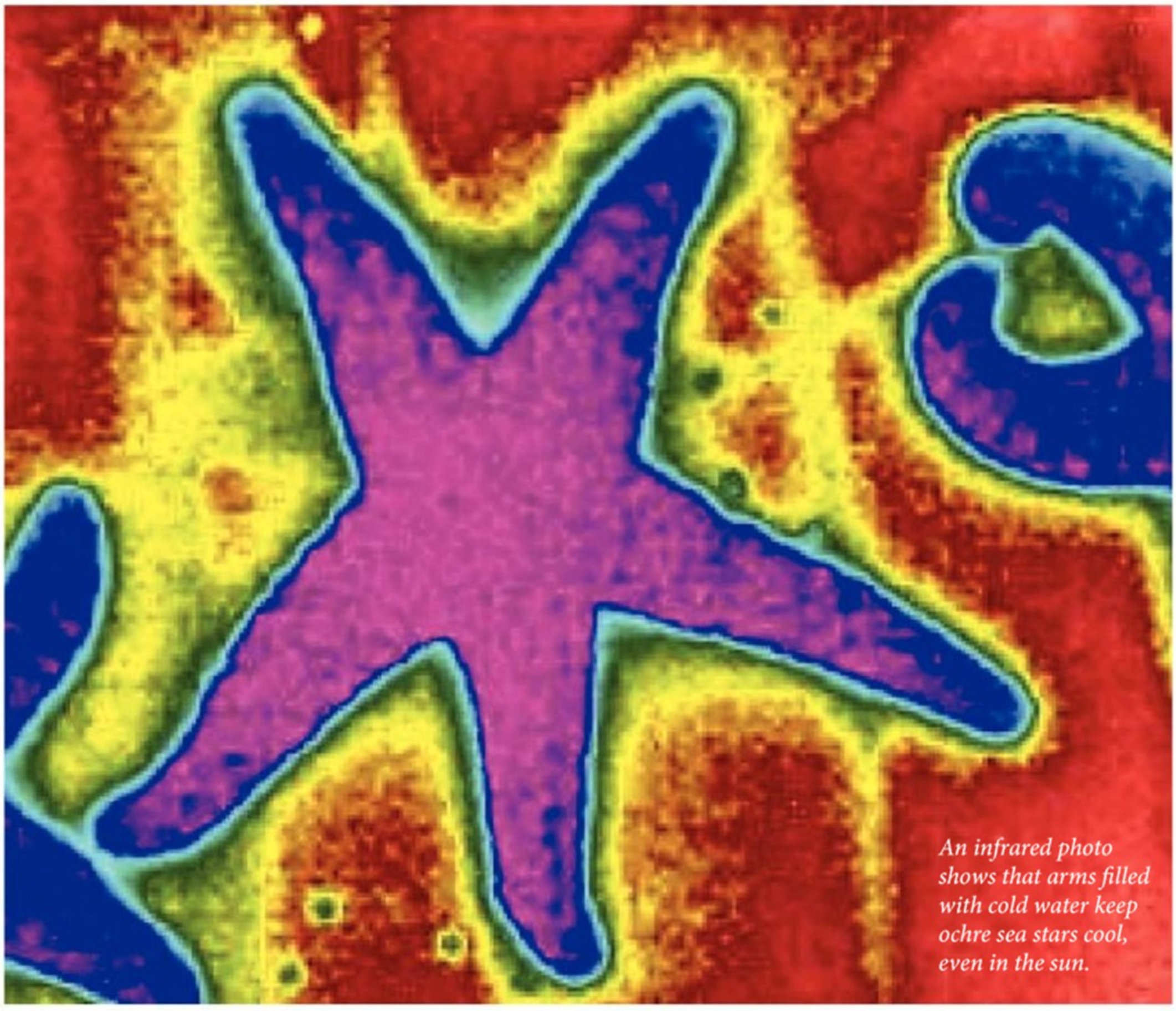


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An infrared photo shows that arms filled with cold water keep ochre sea stars cool, even in the sun.

Stars in the Sun An exposed ochre sea star may appear to bask in the sun, but air that's warmer than 73°F can harm—and, at 95°F, kill—this icon of the North Pacific coast. How does it keep its cool? By taking the temperature, then using its five-armed, balloon-like anatomy.

A team of biologists in Bodega Bay, California, say sea stars use their time during low tide to assess the air. When waves roll in and submerge them, they fill cavities in their arms with frigid water, taking in more or less, based on the perceived air temperature. During low tide, those arms act like cold packs in a lunch bag, slowing heating.

Yet these animals are also susceptible to changes in water temperature. Much like trying to chill a sandwich with cold packs left out overnight, the sea star's cooling system will fail if sea temperatures rise. Because it plays an outsize role in its ecosystem, the consequences could be worse than a spoiled lunch. *—Juli Berwald*



SNAP, CRACKLE, POP For such a modest creature, the two-inch-long snapping shrimp creates quite a racket. Also known as the pistol shrimp, the crustacean possesses an outsize claw that it cocks open and snaps shut at lightning speed. This motion generates tiny bubbles that implode, sending a shock wave at small crabs, worms, and other unlucky targets. The little blasts stun prey and, when emanating from colonies up to 300 shrimps strong, produce a collective crackle loud enough to interfere with sonar transmissions. Strength in numbers, indeed. *—Catherine Zuckerman*

PHOTO (TOP): SYLVAIN PINCEBOURDE. ART: STEFAN FICHTEL











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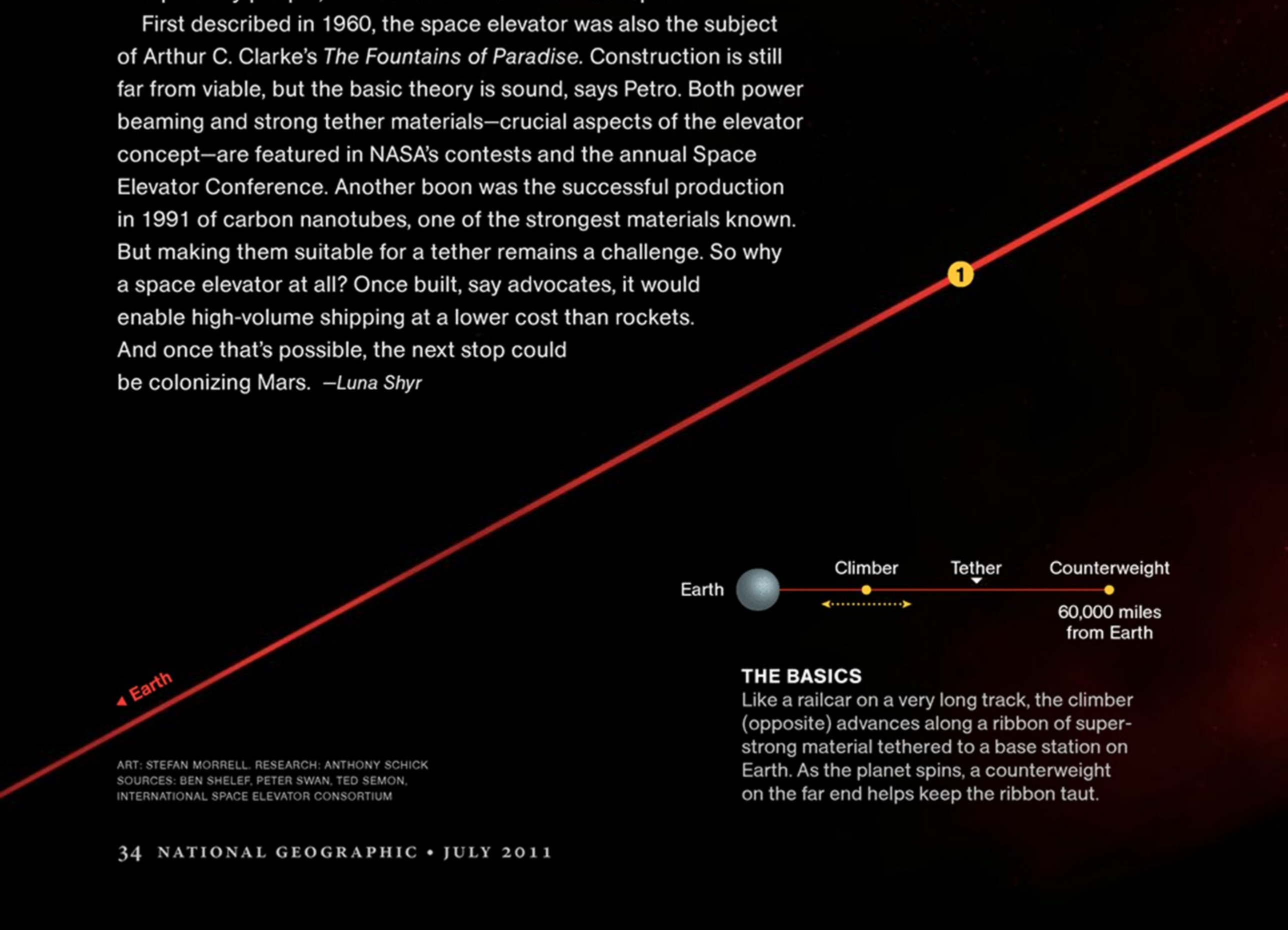
NEXT

SPACE ELEVATOR

A tethered cargo hold could ferry goods to space.

In 2009 NASA's Andrew Petro watched as a laser-powered robotic device climbed up a cable more than half a mile long above the Mojave Desert. A winner in the agency's Centennial Challenges program—competitions designed to stimulate innovative research—the setup demonstrated the potential of wireless power transmission. That, along with work on superstrong materials, is creating fresh hope for a vision long the realm of science fiction: an elevator that can carry cargo, and possibly people, thousands of miles into outer space.

First described in 1960, the space elevator was also the subject of Arthur C. Clarke's *The Fountains of Paradise.* Construction is still far from viable, but the basic theory is sound, says Petro. Both power beaming and strong tether materials—crucial aspects of the elevator concept—are featured in NASA's contests and the annual Space Elevator Conference. Another boon was the successful production in 1991 of carbon nanotubes, one of the strongest materials known. But making them suitable for a tether remains a challenge. So why a space elevator at all? Once built, say advocates, it would enable high-volume shipping at a lower cost than rockets. And once that's possible, the next stop could be colonizing Mars. —*Luna Shyr*



THE BASICS
Like a railcar on a very long track, the climber (opposite) advances along a ribbon of super-strong material tethered to a base station on Earth. As the planet spins, a counterweight on the far end helps keep the ribbon taut.

ART: STEFAN MORRELL. RESEARCH: ANTHONY SCHICK
SOURCES: BEN SHELEF, PETER SWAN, TED SEMON, INTERNATIONAL SPACE ELEVATOR CONSORTIUM

Laser light beamed from Earth

Counterweight

1

2

3

4

1 THE TETHER
Carbon nanotubes—molecular strands of carbon that are many times stronger than steel—show the greatest promise for a material strong and light enough to serve as a tether. A flat and curved ribbon shape would help minimize damage from space debris.

2 PHOTOVOLTAIC PANEL
Photovoltaic cells on the underside absorb laser light beamed from a base station; the laser energy is then converted into electricity to propel the climber. Solar cells on top provide additional power.

3 THE DRIVE
Like rollers on a printing press, multiple wheels clamp on to the tether and spin to move the climber along. Maintaining several points of contact on the ribbon helps keep the weight distributed.



4 CARGO HOLD
Basic models envision a 14-ton hold about the size of an 18-wheeler's trailer, but the size could vary, depending on the tether. Aluminum, used in airplanes and spacecraft, is a good candidate for construction.

Farewell to Guinea Worm

It's not every day that a disease disappears, but guinea worm disease may be next, after smallpox. Thanks to international efforts led by the Carter Center, just 1,797 cases were reported worldwide last year, most in what is now South Sudan. In 2012 public health officials aim to push that number down to zero.



The triumph hasn't been easy; guinea worm isn't vulnerable to vaccines or medication. The eradication effort's primary weapon: education. Local volunteers teach African villagers to strain potentially contaminated water through fabric or filter-equipped straws (above). They explain the worm's life cycle, so that people with emerging worms will avoid entering stagnant water, like ponds, where larvae are deposited. The searing pain caused when the worms exit the body often leaves victims unable to work during key farming periods. But armed with knowledge and tools, communities are close to wiping out this ancient disease. *—Nancy Shute*



In Ghana, health workers massage a child's ankle to aid the gradual extraction of a mature guinea worm (left). The worms can grow more than a yard long and emerge slowly, often over several weeks. A preserved specimen (above) is about a foot long.

PHOTOS (CLOCKWISE FROM BOTTOM): PETER DICAMPO, VII MENTOR PROGRAM; KAREN KASMAUSKI, CORBIS; MARTIN OEGGERLI WITH YVETTE ENDRISS, SWISS TROPICAL INSTITUTE, BASEL

"We've never seen the real human brain before."
—Harvard professor Van Wedeen on the promise of new brain-imaging techniques



A novel type of brain scan reveals a healthy adult's neural circuitry and travel pathways.

New Looks at the Brain

We like to brag about our gray matter, linking smarts to brain cells. But for neuroscientists, it's also about white matter, the spaghetti-like tangle of nerve fibers, and the networks that carry information between regions of the brain. Who we are—our memories, thoughts, emotions—derives from these wiring connections. The problem was no devices existed to see and decode the neural maze in live subjects. That's now changing.

With $40 million in federal support, U.S. research teams are using cutting-edge scanners to create a library of "connectomes"—maps of the brain's circuitry that promise to reveal how the organ responds to aging, learning, and other events. Data from the Human Connectome Project may provide insights into treating autism and schizophrenia.

In a test image (above), what looks like a clown's wig is a color-coded depiction of routes created by a brain's neural pathways. Each strand represents thousands of nerve fibers called axons. The picture's creator, Harvard professor Van Wedeen, has devised a 3-D imaging process that unveils the connections by tracing the movement of water along fiber tissues. "The brain is so organized," he marvels. "That's its true beauty." *—Tom O'Neill*

BRAINSTORMS

NASA's Kepler telescope has spied a **NEW PLANETARY SYSTEM**—six bodies orbiting a sunlike star 2,000 light-years from Earth. • Cancer researchers at MIT are developing a **TUMOR-TRACKING IMPLANT** the size of a rice grain. • In Brazil **TROPICAL FRUIT FIBERS** have been identified as stronger, lighter, and renewable alternatives to plastics used in building cars. • The Centers for Disease Control and Prevention now puts the **AVERAGE U.S. LIFE EXPECTANCY** above 78.

IMAGE: VAN WEDEEN, HARVARD/MASSACHUSETTS GENERAL HOSPITAL; PATRIC HAGMANN, VAUDOIS UNIVERSITY HOSPITAL, LAUSANNE, SWITZERLAND

The Search for Cleopatra

By Chip Brown

An Egyptian gold bracelet from around the time of Cleopatra takes the shape of two coiled snakes, symbols of protection and regeneration.

KENNETH GARRETT, AT EGYPTIAN MUSEUM, CAIRO

Where, oh where is Cleopatra? She's everywhere, of course—her name immortalized by slot machines, board games, dry cleaners, exotic dancers, and even a Mediterranean pollution-monitoring project. She is orbiting the sun as the asteroid 216 Kleopatra. Her "bath rituals and decadent lifestyle" are credited with inspiring a perfume. Today the woman who ruled as the last pharaoh of Egypt and who is alleged to have tested toxic potions on prisoners is instead poisoning her subjects as the most popular brand of cigarettes in the Middle East. § In the memorable phrase of critic Harold Bloom, she was the "world's first celeb-rity." If history is a stage, no actress

These statue parts—the head of a Roman woman and the body of one of Cleopatra's ancestors—were uncovered during almost 20 years of excavations off the coast of Alexandria, Cleopatra's capital. Much of the city and the area around it sank during centuries of earthquakes, tsunamis, and rising seas.

CHRISTOPH GERIGK, FRANCK GODDIO/HILTI FOUNDATION

was ever so versatile: royal daughter, royal mother, royal sister from a family that makes the Sopranos look like the Waltons. When not serving as a Rorschach test of male fixations, Cleopatra is an inexhaustible muse. To a recent best-selling biography add—from 1540 to 1905—five ballets, 45 operas, and 77 plays. She starred in at least seven films; an upcoming version will feature Angelina Jolie.

Yet if she is everywhere, Cleopatra is also nowhere, obscured in what biographer Michael Grant called the "fog of fiction and vituperation which has surrounded her personality from her own lifetime onwards." Despite her reputed powers of seduction, there is no reliable depiction of her face. What images do exist are based on unflattering silhouettes on coins. There is an unrevealing 20-foot-tall relief on a temple at Dendera, and museums display a few marble busts, most of which may not even be of Cleopatra.

Ancient historians praised her allure, not her looks. Certainly she possessed the ability to roil passions in two powerful Roman men: Julius Caesar, with whom she had one son; and Mark Antony, who would be her lover for more than a decade and the father of three more children. But her beauty, said Greek historian Plutarch, was not "the sort that would astound those who saw her; interaction with her was captivating, and her appearance, along with her persuasiveness in discussion and her character that accompanied every interchange, was stimulating. Pleasure also came with the tone of her voice, and her tongue was like a many-stringed instrument."

People have been puzzling over the whereabouts of Cleopatra's tomb since she was last seen in her mausoleum in the legendary deathbed tableau, adorned with diadem and royal finery and reposed on what Plutarch described as a golden couch. After Caesar's assassination, his heir Octavian battled Antony for control of the Roman Empire for more than a decade; following Antony and Cleopatra's defeat at Actium, Octavian's forces entered Alexandria in the summer of 30 B.C. Cleopatra barricaded herself behind her mausoleum's massive doors, amid stores of gold, silver, pearls, art, and other treasures that she vowed to torch lest they fall into Roman hands.

It was to the mausoleum that Antony, dying of self-inflicted sword wounds, was brought on the first of August so he might take a last sip of wine and perish in Cleopatra's arms. And it may have been in the mausoleum where, ten days or so after Antony's death, Cleopatra herself escaped the humiliation of defeat and captivity by committing suicide at the age of 39, reputedly with the venom of an asp. The Roman historian Dio Cassius reported that Cleopatra's body was embalmed as Antony's had been, and Plutarch noted that on the orders of Octavian, the last queen of Egypt was buried beside her defeated Roman consort. Sixteen centuries later Shakespeare proclaimed: "No grave upon the earth shall clip in it / a pair so famous."

And yet we have no idea where that grave might be. The wealth of attention paid to Cleopatra by artists seems inversely proportional to the poverty of material generated about her by archaeologists. Alexandria and its environs attracted less attention than the more ancient sites along the Nile, such as the Pyramids at Giza or the monuments at Luxor. And no wonder: Earthquakes, tidal waves, rising seas, subsiding ground, civil conflicts, and the unsentimental recycling of building stones have destroyed the ancient quarter where for three centuries Cleopatra and her ancestors lived. Most of the glory

Experts believe that this marble bust with a royal headband may represent Cleopatra and was perhaps made while she was in Rome. Some features, such as the curve of her nose, match her official portraits on coins. Ancient authors say she captivated people with her intelligence, quick wit, and charisma. Two of the world's most powerful men fell for her—Julius Caesar and Roman general Mark Antony.

"MARBLE PORTRAIT OF CLEOPATRA VII," CA 50-30 B.C.; CHRISTOPH GERIGK, AT ALTES MUSEUM, BERLIN

that was ancient Alexandria now lies about 20 feet underwater.

In the past few decades archaeologists have finally taken up the mystery of Cleopatra's whereabouts and are searching for her burial place in earnest. Underwater excavations begun in 1992 by French explorer Franck Goddio and his European Institute of Underwater Archaeology have allowed researchers to map out the drowned portions of ancient Alexandria, its piers and esplanades, the sunken ground once occupied by royal palaces. The barnacled discoveries brought to the sea's surface—massive stone sphinxes, giant limestone paving blocks, granite columns and capitals—whet the appetite for a better understanding of Cleopatra's world.

"My dream is to find a statue of Cleopatra—with a cartouche," says Goddio. So far, however, the underwater work has failed to yield a tomb. The only signs of Cleopatra the divers have encountered are the empty cigarette packs that bear her name, drifting in the water as they work.

More recently, a desert temple outside Alexandria has become the focus of another search, one that asks whether a monarch of Cleopatra's calculation and foresight might have provided a tomb for herself in a place more spiritually significant than downtown Alexandria—some sacred spot where her mummified remains could rest undisturbed beside her beloved Antony.

In November 2006 at his office in Cairo, Zahi Hawass, then secretary-general of the Supreme Council of Antiquities, pulled out a sheet of Nile Hilton stationery. On it he had sketched the highlights of an archaeological site where he and a team of scientists and excavators had been digging over the previous year. "We are searching for the tomb of Cleopatra," he said, excitedly. "Never before has anyone systematically looked for the last queen of Egypt." This particular quest had begun when a woman from the Dominican Republic named Kathleen Martinez contacted Hawass in 2004 and came to share a theory she'd developed: that Cleopatra might be buried in a tumbledown temple near the coastal desert town of Taposiris Magna (present-day Abu Sir), 28 miles west of Alexandria.

Located between the Mediterranean and Lake Mareotis, the ancient city of Taposiris Magna had been a prominent port town during Cleopatra's time. Its vineyards were famous for their wine. The geographer Strabo, who was in Egypt in 25 B.C., mentioned that Taposiris staged a great public festival, most likely in honor of the god Osiris. Nearby was a rocky seaside beach, he said, "where crowds of people in the prime of life assemble during every season of the year."

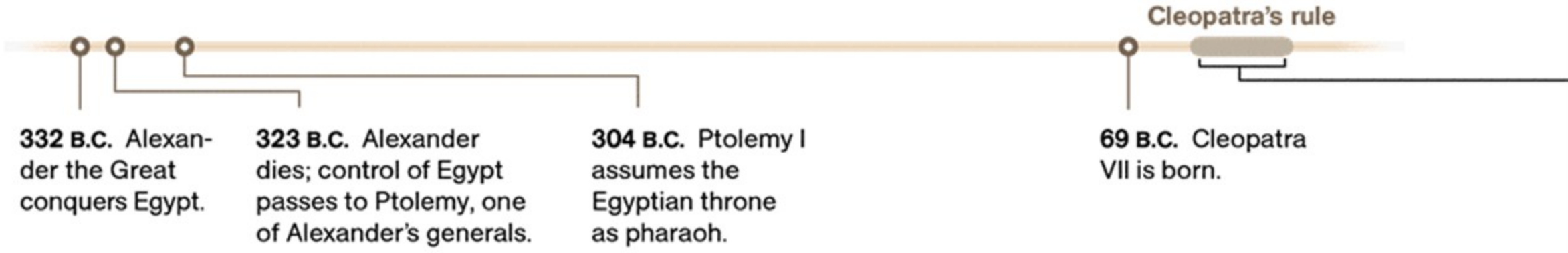
"I thought before we started digging that Cleopatra would be buried facing the palace in Alexandria, in the royal tombs area," said Hawass. But in time, Martinez's reasoning persuaded him another theory might be worth exploring: that Cleopatra had been clever enough to make sure she and Antony were secretly buried where no one would disturb their eternal life together.

A child prodigy who'd earned her law degree at the age of 19, Kathleen Martinez was teaching archaeology at the University of Santo Domingo, but it was an avocation; she'd never been to Egypt or handled a trowel. She traced her obsession with Cleopatra to an argument she'd had with her father in 1990, when she was 24 years old. She wandered into his library one day looking for a copy of Shakespeare's *Antony and*

Chip Brown reported in April 2009 on the identification of a mummy believed to be Hatshepsut, an Egyptian queen who ruled as a king.

THE LAST OF THE PHARAOHS

Cleopatra was a Macedonian Greek and a descendant of Ptolemy, the general of Alexander the Great who founded a dynasty that ruled Egypt for three centuries. She committed suicide as Rome seized control of Egypt, ending 3,000 years of pharaonic rule.



Cleopatra. Her father, Fausto Martínez, a professor and legal scholar normally quite careful in his judgments, disparaged the famous queen as a trollop. "How can you say that!" she protested. After an hours-long debate in which Kathleen argued that Roman propaganda and centuries of bias against women had distorted Cleopatra's character, Professor Martínez conceded that his opinion of Cleopatra might have been unfair.

From that moment Martinez resolved to learn everything she could about the queen. She pored over the canonical texts, particularly Plutarch's account of Mark Antony's alliance with Cleopatra. It seemed clear that the Romans had been intent on depicting her (at worst) as a decadent and lustful despot and (at best) as a manipulative politician who'd played the bitter factions of the emerging Roman superpower against each other in a desperate bid to preserve Egypt's autonomy. It was also possible that modern-day researchers might have missed important clues about where Cleopatra was buried.

"You cannot find anything in any ancient writing about where Cleopatra is buried," Martinez said. "But I believe she prepared everything, from the way she lived to the way she died to the way she wanted to be found."

In 2004 she emailed Hawass. She did not receive a reply. Unable to have herself smuggled into Hawass's office inside a sack—the famous stratagem by which the 21-year-old Cleopatra is supposed to have acquainted herself with Julius Caesar in 48 B.C.—Martinez assailed him with emails, upwards of a hundred by her estimate. Again, no reply. She headed for Cairo and eventually wangled an audience with Hawass through a guide who had worked for the Supreme Council of Antiquities.

"Who are you and what do you want?" Hawass asked when Martinez arrived in his office in the fall of 2004. She did not explain that she was searching for Cleopatra, worried that he would lump her in with the nuts who believe aliens built the pyramids. "I want to visit places that aren't open to the public," Martinez explained. Hawass granted her permission to visit sites in Alexandria, Giza, and Cairo.

Martinez returned to Egypt in March 2005, calling on Hawass with the news that she had been appointed an ambassador of culture by the Dominican Republic. He laughed and said she was too young to be an ambassador. She told him she'd visited Taposiris Magna the previous year and wanted to go back. There were remnants of a Coptic church on the site, and Dominicans were interested in the history of Christianity. Hawass again said yes.

After she had photographed and walked the site, she again called on Hawass. "You have two minutes," he said. *(Continued on page 56)*



Cleopatra's kingdom at greatest extent, 34-31 B.C.

To stabilize the eastern Mediterranean, Mark Antony gave lands beyond the Nile to Cleopatra, the strongest local ruler. This restored some, but not all, of the territory Egypt had once controlled.

Kingdom at greatest extent, 34-31 B.C.

51 B.C. Cleopatra ascends to the throne.

47 B.C. Son with Julius Caesar is born.

44 B.C. Julius Caesar is killed in Rome.

40 B.C. Twins with Mark Antony are born. Another son is born in 36 B.C.

31 B.C. Cleopatra and Antony are defeated by Octavian at the Battle of Actium.

30 B.C. Cleopatra and Antony die; Egypt falls under Roman rule.

That's Cleopatra on the left side of a wall at a temple at Dendera—one of the few images that bear her name. She is shown fulfilling her role as pharaoh by making offerings to the gods. The appearance here of her son by Julius Caesar is propaganda aimed at strengthening his position as her heir. He was captured and executed shortly after her demise.

GEORGE STEINMETZ





NIMATALLAH/ART RESOURCE



The exotic Nile of Cleopatra's era comes to life on a monumental floor mosaic in Palestrina, Italy. Starting in Ethiopia at the top, the river flows past pharaonic and Greco-Egyptian temples, winds through the delta, and ends in what may be Alexandria's busy harbor at bottom right.

The temples of Philae rise from an island in the Nile just south of Aswan. Ptolemaic pharaohs constructed much of this complex, which served as a center of worship for the goddess Isis. Cleopatra identified herself with the popular deity, as did most of the dynasty's queens.

JACK KOTZ



Cleopatra's Alexandria

Founded by Alexander the Great in 331 B.C., this Mediterranean city became the world's most magnificent center of trade, culture, and learning under the Ptolemies. Ruins of the ancient buildings now lie under the sea and beneath modern construction. This re-creation shows what the city may have looked like during Cleopatra's reign, when a multicultural mix of perhaps 325,000 people made it their home.



Taposiris Magna
The search for the tomb of Cleopatra and Mark Antony extends to the temple ruins of this town connected to gods Isis and Osiris.



Isis sculpture from Taposiris Magna



Taposiris Magna temple complex

Lake Mareotis
Linked by canals to the Nile and Mediterranean, this lake—vital to shipping in Cleopatra's day, when Egypt supplied much of Rome's grain—is now much smaller.



The Heptastadium was a causeway, a harbor breakwater, and an aqueduct bringing water to Pharos Island.

Ancient accounts describe the city's grand east-west boulevard as a hundred feet wide.

Shifting shore
Earthquakes, rising seas, sinking land, and new construction have dramatically reshaped the ancient coast and harbors shown here.

FERNANDO G. BAPTISTA AND AMANDA HOBBS, NGM STAFF
ART: JAIME JONES. NGM MAPS

SOURCES: EUROPEAN INSTITUTE OF UNDERWATER ARCHAEOLOGY (IEASM); *EGYPT'S SUNKEN TREASURES: THE ANCIENT CITY OF ALEXANDRIA*, ASAHI SHIMBUN AND TOPPAN PRINTING; JUDITH McKENZIE, *THE ARCHITECTURE OF ALEXANDRIA AND EGYPT*; DUANE W. ROLLER, OHIO STATE UNIVERSITY

(Continued from page 47) The time had come to drop the veil. Martinez explained to him that she wanted to excavate at Taposiris. "I have a theory," she said, and finally confided that she thought Taposiris Magna was where Cleopatra was buried.

"What?" said Hawass, grabbing his chair. A group of Hungarian archaeologists had just concluded excavations at the site, and French archaeologists had excavated Roman baths just outside the walls of the temple. Plans were pending to turn Taposiris Magna into a tourist attraction.

"Give me two months," Martinez countered. "I will find her."

Cleopatra VII was born in Egypt, but she was descended from a lineage of Greek kings and queens who had ruled Egypt for nearly 300 years. The Ptolemies of Macedonia are one of history's most flamboyant dynasties, famous not only for wealth and wisdom but also for bloody rivalries and the sort of "family values" that modern-day exponents of the phrase would surely disavow, seeing as they included incest and fratricide.

The Ptolemies came to power after the conquest of Egypt by Alexander the Great, who in a caffeinated burst of activity beginning in 332 B.C. swept through Lower Egypt, displaced the hated Persian occupiers, and was hailed by the Egyptians as a divine liberator. He was recognized as pharaoh in the capital, Memphis. Along a strip of land between the Mediterranean and Lake Mareotis he laid out a blueprint for Alexandria, which would serve as Egypt's capital for nearly a thousand years.

After Alexander's death in 323 B.C., Egypt was given to Ptolemy, one of his trusted generals, who, in a brilliant bit of marketing, hijacked the hearse bearing Alexander's body back to Greece and enshrined it in a tomb in Alexandria. Ptolemy was crowned pharaoh in 304 B.C. on the anniversary of Alexander's death. He made offerings to the Egyptian gods, took an Egyptian throne name, and portrayed himself in pharaonic garb.

The dynasty's greatest legacy was Alexandria itself, with its hundred-foot-wide main avenue, its gleaming limestone colonnades, its harborside palaces and temples overseen by a towering lighthouse, one of the seven wonders of the ancient world, on the island of Pharos. Alexandria soon became the largest, most sophisticated city on the planet. It was a teeming cosmopolitan mix of Egyptians, Greeks, Jews, Romans, Nubians, and other peoples. The best and brightest of the Mediterranean world came to study at the Mouseion, the world's first academy, and at the great Alexandria library.

It was there, 18 centuries before the Copernican revolution, that Aristarchus posited a heliocentric solar system and Eratosthenes calculated the circumference of the Earth. Alexandria was where the Hebrew Bible was first translated into Greek and where the poet Sotades the Obscene discovered the limits of artistic freedom when he unwisely scribbled some scurrilous verse about Ptolemy II's incestuous marriage to his sister. He was deep-sixed in a lead-lined chest.

The Ptolemies' talent for intrigue was exceeded only by their flair for pageantry. If descriptions of the first dynastic festival of the Ptolemies around 280 B.C. are accurate, the party would cost millions of dollars today. The parade was a phantasmagoria of music, incense, blizzards of doves, camels laden with cinnamon, elephants in golden slippers, bulls with gilded horns. Among the floats was a 15-foot Dionysus pouring a libation from a golden goblet.

Where could they go from there but down? By the time Cleopatra VII ascended the throne in 51 B.C. at age 18, the Ptolemaic empire was crumbling. The lands of Cyprus, Cyrene (eastern Libya), and parts of Syria had been lost; Roman troops were soon to be garrisoned in Alexandria itself. Still, despite drought and famine and the eventual outbreak of civil war, Alexandria was a glittering city compared to provincial Rome. Cleopatra was intent on reviving her empire, not by thwarting the growing power of the Romans but by making herself useful to them, supplying them with ships and grain, and sealing her

alliance with the Roman general Julius Caesar with a son, Caesarion.

Lest her subjects resent her Roman overtures, Cleopatra embraced Egypt's traditions. She is said to have been the first Ptolemaic pharaoh to bother to learn the Egyptian language. While it was politic for foreign overlords to adopt local deities and appease the powerful religious class, the Ptolemies were genuinely intrigued by the Egyptian idea of an afterlife. Out of that fascination emerged a hybrid Greek and Egyptian religion that found its ultimate expression in the cult of Serapis—a Greek gloss on the Egyptian legend of Osiris and Isis.

One of the foundational myths of Egyptian religion, the legend tells how Osiris, murdered by his brother Seth, was chopped into pieces and scattered all over Egypt. With power gained by tricking the sun god, Re, into revealing his secret name, Isis, wife and sister of Osiris, was able to resurrect her brother-husband long enough to conceive a son, Horus, who eventually avenged his father's death by slaughtering uncle Seth.

By Cleopatra's time a cult around the goddess Isis had been spreading across the Mediterranean for hundreds of years. To fortify her position, and like other queens before her, Cleopatra sought to link her identity with the great Isis (and Mark Antony's with Osiris), and to be venerated as a goddess. She had herself depicted in portraits and statues as the universal mother divinity.

Beginning in 37 B.C., Cleopatra began to realize her ambition to enlarge her empire when Antony restored several territories to Egypt and decreed Cleopatra's children their sovereigns. She appeared in the holy dress of Isis at a festival staged in Alexandria to celebrate Antony's victory over Armenia in 34 B.C., just four years before her suicide and the end of the Egyptian empire.

It was Cleopatra's intense identification with Isis, and her royal role as the manifestation of the great goddess of motherhood, fertility, and magic, that ultimately led Kathleen Martinez to Taposiris Magna. Using Strabo's ancient descriptions of Egypt, Martinez sketched a map of candidate burial sites, zeroing in on 21 places associated with the legend of Isis and Osiris and visiting each one she could find.

"What brought me to the conclusion that Taposiris Magna was a possible place for Cleopatra's hidden tomb was the idea that her death was a ritual act of deep religious significance carried out in a very strict, spiritualized ceremony," Martinez says. "Cleopatra negotiated with Octavian to allow her to bury Mark Antony in Egypt. She wanted to be buried with him because she wanted to reenact the legend of Isis and Osiris. The true meaning of the cult of Osiris is that it grants immortality. After their deaths, the gods would allow Cleopatra to live with Antony in another form of existence, so they would have eternal life together."

After studying more than a dozen temples, Martinez headed west of Alexandria along the coastal road to explore the ruin she had begun to believe was the last, best hope for her theory. The temple at Taposiris Magna had been dated to the reign of Ptolemy II, though it may have been even older. The suffix Osiris in its name implied the site was a sacred spot, one of at least 14 throughout Egypt where legend holds that the body of Osiris (or a dismembered part of it) had been buried.

With the Mediterranean on her right and Lake Mareotis on the left, Martinez mused on the possibility that Cleopatra might have traveled a similar route, selecting this strategic location for her burial because it was inside the limits of ancient Alexandria and not yet under the control of the Romans during those last days before her death. "When I saw the place my heart beat very fast," she recalls. As she walked the site, she trailed her hands along the white and beige limestone blocks of the temple's enclosure. This is it! she thought. This is it!

In 1935 British traveler Anthony de Cosson had called Taposiris Magna "the finest ancient monument left to us north of the Pyramids." What was surprising was how little work had been done at the site. In 1905 Evaristo Breccia,

The time had come to drop the veil. "I have a theory," Martinez said, and confided she thought Taposiris Magna was where Cleopatra was buried. "What?" said Hawass, grabbing his chair.

the renowned Italian archaeologist, had excavated the foundation of a small fourth-century A.D. Coptic basilica in the otherwise vacant courtyard of the enclosure and discovered an area of Roman baths. In 1998 a Hungarian team led by Győző Vörös found evidence of a colonnaded structure inside the enclosure that they concluded (incorrectly, as it turned out) had been an Isis temple.

It was clear when Vörös's book, *Taposiris Magna,* was published in 2004 that the temple had had three incarnations—as a Ptolemaic sanctuary, a Roman fort, and a Coptic church. But was that the whole story? Zahi Hawass found himself pondering the possibility that a black granite bust of Isis that Vörös had coaxed from the dirt of Taposiris Magna might well be the face of Cleopatra herself. In October 2005 the dig got under way.

Today it's easy to imagine that the view from the pylon of Taposiris Magna looks much like it did in Cleopatra's day—if you can block out the unsightly band of condominiums and resort hotels between the coastal highway and the broad white sand beach and glimmering blue expanse of the Mediterranean. One hot, sun-washed morning at the temple in May 2010, Kathleen Martinez was bundled in a long-sleeve shirt, head scarf, and fingerless woolen gloves. "For some reason I am always cold when I am here," she said. The two months of excavation she had requested had turned into three months, and three months had become five years.

On the bedrock in the middle of the site an array of column fragments showed the ghostly outlines of what Hawass and Martinez have concluded was not a temple to Isis, but a temple to Osiris. It was oriented on the east-west axis. At an angle just north were the faint hints of an Isis chapel; to the south, an excavated rectangular pit: "That was the sacred lake," Martinez says.

It's a cliché that you can stick a shovel in the ground almost anywhere in Egypt and find something amazing from the long-gone past. When Martinez and a team of excavators began probing the ground in 2005, she was focused less on the ultimate prize of Cleopatra's tomb than on simply finding sufficient evidence to sustain her theory that Taposiris Magna might be the place to look. She hoped to demonstrate that the temple was among the most sacred of its day, that it was dedicated to the worship of Osiris and Isis, and that tunnels had been dug underneath the enclosure walls. Within the first year, she was rewarded by the discovery of a shaft and several underground chambers and tunnels. "One of our biggest questions is why did they dig tunnels of this magnitude," she says. "It had to be for a very significant reason."

During the 2006-07 season the Egyptian-Dominican team found three small foundation deposits in the northwest corner of the Osiris temple, just inches from where the Hungarian expedition had stopped digging. The deposits conclusively linked the Osiris temple to the reign of Ptolemy IV, who ruled a century and a half before Cleopatra. In 2007, further supporting the view that the site was very important to the Greeks of ancient Egypt, the excavators found a skeleton of a pregnant woman who had died in childbirth. The tiny bones of the unborn baby lay between the skeleton's hips. Her jaw was distended, suggesting her agony, and her right hand was clutching a small white marble bust of Alexander the Great. "She is a mystery," said Martinez, who had a coffin built for the remains of the mother.

In six years Taposiris Magna has become one of Egypt's most active archaeology sites. More

The top half of a granite colossus is hoisted to the surface of Aboukir Bay, northeast of Alexandria. About 18 feet tall, the full sculpture represented Hapy, the god of the Nile's yearly flooding, which fertilized Egypt's fields. It likely stood outside the major temple in Herakleion. That long-lost city, now rediscovered underwater, was a center of trade and pilgrimage and a ritual site for Cleopatra and other Ptolemaic pharaohs.

CHRISTOPH GERIGK, FRANCK GODDIO/HILTI FOUNDATION



Treasures from the sunken ruins of the city of Canopus—pendants, beads, clasps, a fan-shaped appliqué, and pieces of other adornments—conjure up legends of Cleopatra's lavish lifestyle. Such wealth helped motivate Rome's conquest of Egypt, which brought access to the gold mines in Nubia and the caravans that

CHRISTOPH GERIGK, FRANCK GODDIO/HILTI FOUNDATION, AT GRECO-ROMAN MUSEUM, ALEXANDRIA



delivered other luxuries from farther south. Canopus was notorious for wild celebrations, but it was also the site of a temple to Serapis, the Ptolemaic version of Osiris, god of the afterlife. This spiritual aspect continued into the Byzantine era, when Christian pilgrims may have offered up their valuables in thanks for cures.



than a thousand objects have been recovered, 200 of them considered significant: pottery, coins, gold jewelry, the broken heads of statues (probably smashed by early Christians). An important discovery was a large cemetery outside the temple walls, suggesting that the subjects of a monarch wished to be buried near royal remains.

Yet the tomb of Cleopatra still hovers out of reach, like a tantalizing mirage, and the theory of who is buried at Taposiris Magna still rests more on educated speculation than on facts. Might not Cleopatra's reign have unraveled too quickly for her to build such a secret tomb? A fantastic story, like a horse with wings, flies in the face of the principle of parsimony. But it's a long hard haul from not-yet-proved to disproved.

Critics of Martinez's theory point out that it is rare in archaeology for someone to announce they are going to find something and then actually find it. "There is no evidence that Cleopatra tried to hide her grave, or would have wanted to," says Duane Roller, a respected Cleopatra scholar. "It would have been hard to hide it from Octavian, the very person who buried her. All the evidence is that she was buried with her ancestors. The material associated with her at Taposiris Magna is not meaningful because material associated with her can be found in many places in Egypt."

"I agree that Octavian knew and authorized the place where she was buried," Martinez says. "But what I believe—and it is only a theory—is that after the mummification process was complete, the priests at Taposiris Magna buried the bodies of Cleopatra and Mark Antony in a different place without the approval of the Romans, a hidden place beneath the courtyard of the temple."

If Cleopatra's tomb *is* ever found, the archaeological sensation would be rivaled only by Howard Carter's unearthing of the tomb of King Tut in 1922. But will finding her tomb, not to say her body itself, deepen our portrait of the last Egyptian pharaoh? On one hand, how could it not? In the last hundred years about the only new addition to the archaeological record is what scholars

If Cleopatra's tomb is found, the archaeological sensation would be rivaled only by Howard Carter's unearthing of King Tut in 1922. But will it deepen our understanding of Egypt's last pharaoh?

believe is a fragment of Cleopatra's handwriting: a scrap of papyrus granting a tax exemption to a Roman citizen in Egypt in 33 B.C.

On the other hand, maybe finding her tomb would diminish what Shakespeare called "her infinite variety." Disembodied, at large in the realm of myth, more context than text, Cleopatra is free to be of different character to different times, which may be the very wellspring of her vitality. No other figure from antiquity seems so versatile in her ambiguities, so modern in her contradictions.

It was lunch hour at the dig site, and the workers had gone to eat in the shade. We were sitting on top of the temple pylon in the radiance of noon, staring out at the sea beyond. There was a feeling of stillness in the air, an inkling of eternity, as if the old Egyptian gods were about—Re, who ruled over the earth, sky, and the underworld, and Isis, who saved Osiris by tricking Re into revealing his secret name.

The search for Cleopatra has come at no small cost to Martinez. She gave up her thriving law practice in Santo Domingo and poured much of her savings into her quest. She moved to an apartment in Alexandria, where she has begun studying Arabic. But it's not an easy life, far from her family and friends. During the revolution earlier this year, she was confronted by a group of aggressive men as she worked at the excavation site. For now, work at the site is on hold. She hopes to return in the fall.

"I believe we are going to find what we are looking for," she says. "The difference is now we're digging in the ground, not in books." □

Slightly larger than life-size, a stone statue from Canopus in the third century B.C. wears a dress typical of Ptolemaic queens. Given the association of those women with Isis, the knot in the fabric is often called an Isis knot. For the Ptolemies, the relationship between Isis and her brother-husband, Osiris, was a model for royal marriages. Her cult endured for 500 years after the death of Cleopatra, one of her devoted followers.

"STATUE OF A QUEEN," THIRD CENTURY B.C.; KENNETH GARRETT



A polar bear rides a summer sea-ice raft off Norway's Svalbard archipelago. Sea ice provides crucial habitat for the Arctic's top predator, but warming temperatures are creating extended ice-free periods that tax bears.

ON THIN ICE



The Arctic is warming so fast that by 2050 it may be largely ice free in summer. Without their frozen hunting platform, how will polar bears survive?

A female polar bear nurses cubs (left) on late July sea ice off Svalbard. Ashore, a male investigates a whale's backbone. Fat reserves from hunting ringed and bearded seals, and sometimes walruses, must carry bears through lean summers.



BY SUSAN McGRATH

PHOTOGRAPHS BY FLORIAN SCHULZ

In August 1881 the naturalist John Muir was sailing off Alaska aboard the steamer *Thomas Corwin,* searching for three vessels that had gone missing in the Arctic. Off Point Barrow he spotted three polar bears, "magnificent fellows, fat and hearty, rejoicing in their strength out here in the bosom of the icy wilderness."

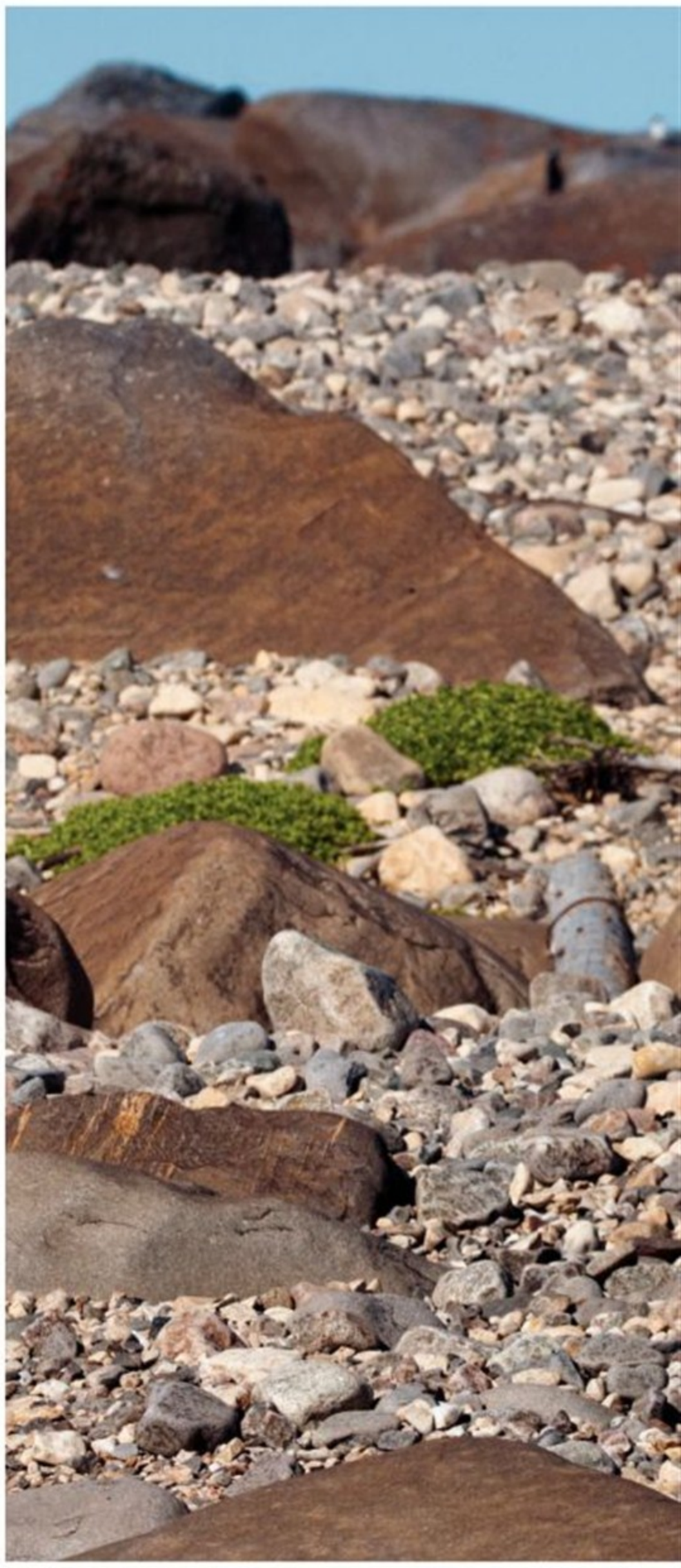
Were Muir to sail off Point Barrow in August today, any polar bears he'd see would not be living in a wilderness of ice but swimming through open water, burning precious fat reserves. That's because the bears' sea-ice habitat is disappearing. And it's going fast.

Polar bears ply the Arctic niche where air, ice, and water intersect. Superbly adapted to this harsh environment, most spend their entire lives on the sea ice, hunting year-round, visiting land only to build maternal birthing dens. They prey mainly on ringed and bearded seals (it's been said that they can smell a seal's breathing hole from more than a mile away) but sometimes catch walruses and even beluga whales.

Sea ice is the foundation of the Arctic marine environment. Vital organisms live underneath and within the ice itself, which is not solid but pierced with channels and tunnels large, small, and smaller. Trillions of diatoms, zooplankton, and crustaceans pepper the ice column. In spring, sunlight penetrates the ice, triggering algal blooms. The algae sink to the bottom, and in shallow continental shelf areas they sustain a food web that includes clams, sea stars, arctic cod, seals, walruses—and polar bears.

Experts estimate the world's polar bear numbers at 20,000 to 25,000, in 19 subpopulations. Bears in Svalbard (the Norwegian archipelago where Florian Schulz made most of these photographs), the Beaufort Sea, and Hudson Bay have been studied the longest. It was in western Hudson Bay, where ice melts in the summer and freezes back to shore in the fall, that the creatures' predicament first came to light.

Ian Stirling, now retired from the Canadian Wildlife Service, has monitored polar bears there since the late 1970s. He found that they gorged on seals in the spring and early summer, before breakup, then retreated to land as the



Impervious to a dive-bombing arctic tern, a hungry bear on the shore of Hudson Bay uses up energy prowling for tern eggs. Summers dry-dock bears around the bay, where biologist Ian Stirling has linked shrinking sea ice to skinnier bears and smaller litters.



ice melted. In a good year, breakup found bears packing a thick layer of fat. Ashore, the bears entered a state known as walking hibernation, their metabolisms on idle to hoard their fat stores. "Until about the early 1990s at Hudson Bay," Stirling says, "bears were able to fast through the open-water season of summer and fall because hunting on the spring sea ice was so good."

During subsequent years of bear-watching, Stirling and a colleague, Andrew Derocher, began to see an alarming pattern. They observed that although the bears' population held steady, the animals were getting thinner. The western Hudson Bay bears were missing vital weeks of peak seal hunting, and the later winter freeze-up was extending their fast. By 1999 the biologists had correlated a steady decline in most measures of polar bear health with a decline in sea ice. Bears didn't grow as large, and some came ashore notably skinnier. Females gave birth less

often and had fewer cubs. Fewer cubs survived.

When that same year Stirling and his colleagues published their findings, it was still possible to doubt that warming in the Arctic had already affected polar bears. In a 1999 interview Steven Amstrup, chief scientist at Polar Bears International, who had studied bears in the Beaufort Sea since 1980 for the U.S. Geological Survey, said he hadn't yet seen the kind of changes Stirling had. Or had he? "My aha! moment," Amstrup recalls, "was when I realized the difficult time I'd been having getting out onto the ice to conduct my autumn fieldwork was not just an odd year or two but a prolonged and worsening trend. Shortly thereafter we began to see the same biological changes in our bears as well."

The world didn't know it yet, but during the summer in the Arctic Ocean, sea ice had been melting earlier and faster, and the winter freeze had been coming later. In the three decades since 1979 the extent of summer ice has declined by about 30 percent. The lengthening period of summer melt threatens to undermine the whole Arctic food web, atop of which stand polar bears.

Data have since bolstered the early warning signs. Since Muir set out in the *Corwin,* greenhouse gases have contributed to an average warming of the Earth of about one degree Fahrenheit. This may seem negligible, but even one degree of warming can noticeably disrupt an environment of ice and snow. It's as if a giant hand has trained a magnifying glass over the Pole.

The sea ice above the shallow continental shelves provides the richest sustenance for polar bears, but recently the ice has been retreating far from those areas, reducing the summer habitat bears need most to survive. Whether a polar bear lives in Hudson Bay or the Beaufort or Barents Seas, it faces the same problem. Sea ice on which to hunt is available for progressively shorter periods, forcing bears to fast for longer periods. And because thinner sea ice is more easily shifted by winds and currents, bears may be swept into strange territory, forcing them to make longer, more arduous swims in open water to find favorable sea ice or to get to land.

Polar bears are strong swimmers, but swimming long distances in open water is draining and can be fatal. In 2008 a radio-collared bear with a yearling cub swam an astounding 427 miles to reach the ice off the northern Alaska coast. The cub didn't make it. Researchers counting bowhead whales in September 2004 spotted four dead polar bears afloat after a storm in the Beaufort Sea. Scientists estimated that as many as 27 bears may have drowned in that one storm.

Females face especially hard times. Malnourished males may kill and eat cubs—and even their mothers—behavior scientists believe may become more common as food diminishes. Increasingly, getting to ancestral denning places on land can be an ordeal. On one island in Svalbard, when the sea has frozen late in the year, scientists have seen few, if any, dens the following spring. That's when they'd normally see 20 or more, Jon Aars, of the Norwegian Polar Institute, says. Whether females find other sites or skip a year of breeding, Aars can't say.

From childhood we create a picture of our physical world: The sky is blue, the Arctic is white. But before this century ends—and perhaps much sooner—most of the Arctic is predicted to be blue water every summer.

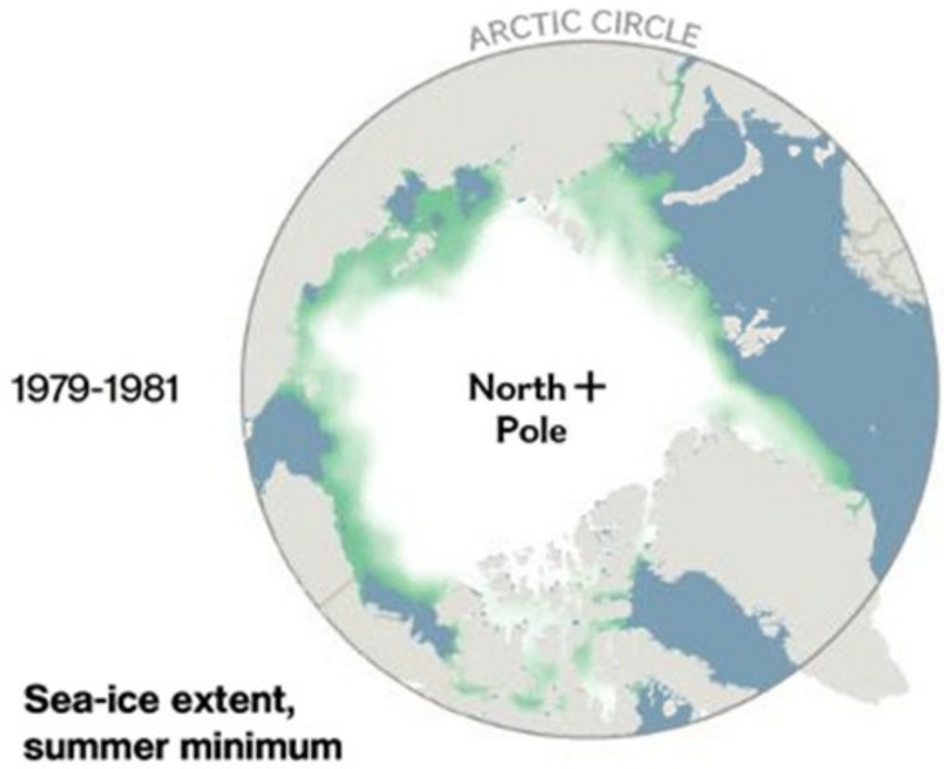
Can a blue Arctic support polar bears? Only in the short run, Amstrup and Stirling say.

Currents still cram drifting sea ice against the Canadian Arctic Islands and northern Greenland in summer, creating pockets that may retain enough ice to support polar bears through this century. If we can reduce the warming of the atmosphere, Amstrup says, it will not be too late for polar bears, but "if the world keeps warming, ultimately even those last refuges will fail to sustain the icon of the Arctic." □

Susan McGrath is a contributing editor at Audubon. *Florian Schulz accompanied the MacGillivray Freeman Films team making* To the Arctic, *a 3-D, IMAX-theater film to be released worldwide this winter. A companion book of Schulz's work in the Arctic will be published by Braided River.*

Bears at sea

The minimum extent of sea ice in summer has declined by about 30 percent since regular satellite monitoring began in 1979; even in winter the ice doesn't fully recover. In some areas females returning to denning sites in autumn face daunting expanses of open water. The Canadian high Arctic and northern Greenland could be the last refuges for polar bears, and even in these areas the ice will disappear if greenhouse gases aren't curbed.





JENNY E. ROSS

Male polar bears may eat young bears (above), so mothers are ever vigilant. Photographer Florian Schulz watched a Svalbard male (below, background) stalk a female with two cubs. “When the female saw him, she huffed at her cubs, and then they just pinned their ears back and ran.” Leaping over floes (right), they kept going long after they’d made good their escape.





BAGHDAD AFTER THE STORM

DESPITE HARDSHIPS AND LINGERING VIOLENCE, RESIDENTS IMAGINE A NEW VERSION OF THE ANCIENT CITY.



On a bridge over the Tigris a man feeds gulls at dawn as water taxis await the morning's first passengers.

Notebooks in hand, young women head to class at the University of Baghdad, passing blast walls plastered with political posters. More than half the 70,000 students are female. The school closed briefly in 2006, after a rash of killings and kidnappings targeted academics.


شفوة وفرح لاسرائيل
اية الفخر في الدنيا والآخرة
له لى القدس

Moviegoers at Baghdad's first 4-D cinema get an extra thrill from shaking seats and wind machines during a 3-D sci-fi film. During the worst years of violence, families stayed home to watch TV or DVDs. Most cinemas closed, as did this one, though it has plans to expand and reopen.



BY BRIAN TURNER
PHOTOGRAPHS BY LYNSEY ADDARIO

I haven't returned to Baghdad to be a war tourist, attuning my eyes to the many long shadows cast by trauma, but it's difficult not to do just that. The last time I was here I wore desert camouflage and carried an M4 carbine as a sergeant in the U.S. Army's Second Infantry Division. That was in 2003 and 2004, when there were up to 150,000 U.S. troops in Iraq. In the years since, I've often wondered what it must be like for Iraqis struggling to reclaim a life for themselves: the welder, the student, the taxi driver, the old woman, the couple getting married. I've also wondered how it would feel to walk down a Baghdad street without a flak vest and 210 rounds of ball ammunition strapped to my chest.



Back then, my unit escorted long, serpentine supply convoys through the city. Insurgents staged complex ambushes, driving cars loaded down with explosives. The black scorch marks of vehicles burned to the ground remained long after their hulks were removed, giving me pause whenever we passed them by. One day our squad leader yelled at my machine gunner and me to drop down from our positions in the hatches at the rear of our Stryker vehicle—and mortar rounds suddenly burst in the air, raining down a deadly spray of shrapnel. We rode through the storm of metal, hearts pounding in our chests. Memories like these reenact themselves in my mind now as we drive through the city, and for a moment I imagine I've returned to Baghdad the way a ghost might haunt the world it once inhabited.

But things have changed. This isn't the Baghdad I once knew. Just off Abu Nuwas Street near the Tigris River, where sniper fire was once a daily hazard, the sounds of war have been replaced by the sounds of children playing soccer on the grass. They whoop, high-pitched and full throated, like birds calling to each other. On Haifa Street, where bitter sectarian fighting raged

Brian Turner is a poet and former GI. Lynsey Addario was captured, then released, by government forces during the uprising in Libya.



BAGHDAD'S TRAFFIC, CHOKED BY HUNDREDS OF CHECKPOINTS, SLOWS TO A CRAWL WHILE SECURITY FORCES INSPECT VEHICLES FOR WEAPONS AND EXPLOSIVES.

from 2006 to 2008, young men pause in the doorway of a local market to finish a conversation as Iraqi pop music blares from a boombox. Near the university several young women laugh as they cradle textbooks and notebooks, their head scarves a splash of color against the drab building facades. Everywhere around Baghdad there is the sound of a city regaining its voice.

When I stepped off the plane, collected my bag from the luggage belt, and walked out into the city, I didn't know what to expect. It was late December 2010. News reports of targeted assassinations via silencer-equipped pistols occupied my thoughts. I couldn't dismiss the possibility of being kidnapped. But as much as my fear counseled me to jump back on that plane, I wanted to know what had become of this place where I'd once come to war. If I was going to meet the new Baghdad, I'd have to put some old habits and memories to the side.

A City of Walls

My first day back I spread out a map of the city on a table in a shaded inner courtyard. It's an outdated map with many red and blue adhesive dots placed on various parts of the city. Many of the names of neighborhoods have changed since the invasion. Saddam City, as it's listed on my old map, for example, now goes by Sadr City, after the deceased Shiite leader Muhammad al

Sadr. The dots create an overall pattern as I step back for a bird's-eye view: blue to one side, red to the other; Shiites dominating the eastern side of the Tigris, Sunnis clustered on the western. The Sunnis have pushed farther west as Shiites have made inroads into neighborhoods adjacent to the river. Although there are still a few mixed neighborhoods, Baghdad is no longer a model secular city of the Middle East, as Iraqis once proudly described it. Years of violence have created a new landscape defined by tribe and religion.

With a population of nearly six million, Baghdad has become a city of walled enclaves regulated by Iraqi Army troops, federal police officers, local policemen, private security guards, and other groups such as the Sons of Iraq, who are like your local Neighborhood Watch crew, only armed with AK-47s. The demarcations are formed by massive concrete blast walls known colloquially as T-walls because they resemble giant T's flipped upside down. Religious flags wave from rooftops, mosques, and intersections in predominately Shiite areas. Sunni neighborhoods are marked by a lack of flags.

"Baghdad is a huge camp, man," says my interpreter, Yousif al-Timimi. "America didn't bring democracy. It brought walls."

The River Taxi

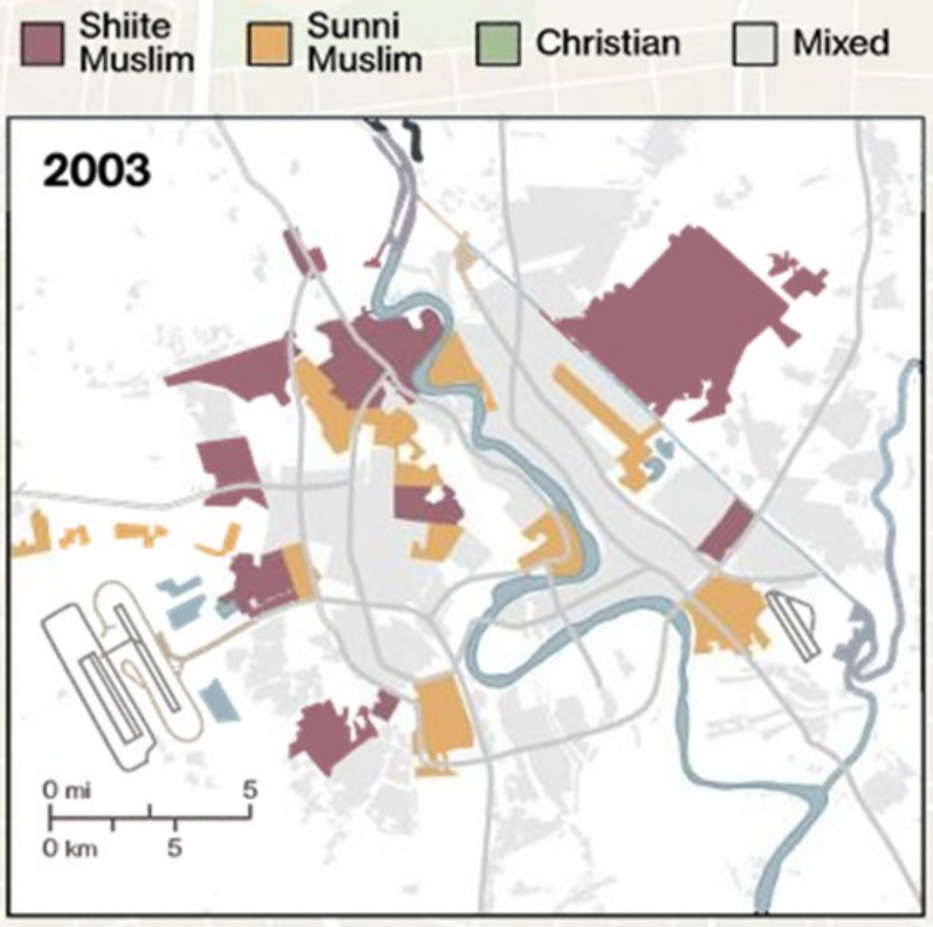
One morning I take a water taxi out onto the Tigris River with a boatman named Ismail, who tells me that he inherited his trade from his father in a tradition stretching back for generations. As he steers the prop with his left hand and talks about his life, I try to push to the back of my mind the fact that we're out in the open, in a clear field of fire, and that a sniper could be in a hide right now debating the physics of his ballistic art—steeped in the contemplation of the elevation and windage, the slight breeze I now feel in my hair, the pitch and yaw of the boat as it slices upriver through the waves, the humidity in the air between us.

And so I focus on the Tigris as it winds its way through the heart of Baghdad. It's a wide river with an unassuming surface of sunlight and shadow, a storied *(Continued on page 92)*

Al Kazimiyah Shrine

BAGHDAD DIVIDED

Many neighborhoods in this city of nearly six million people were a mix of Shiite, Sunni, and Christian families before the U.S.-led invasion toppled Saddam Hussein in 2003 (maps below). After sectarian violence erupted, neighborhoods became segregated by faith, with Shiites increasing their dominance. Christians may now number fewer than half a million in all of Iraq, about a 50 percent drop.



MARGUERITE B. HUNSIKER AND MAGGIE SMITH, NGM STAFF

SOURCES: M. IZADY, GULF/2000 PROJECT, COLUMBIA UNIVERSITY (MAPS, ABOVE); INTERNATIONAL TRAVEL MAPS AND BOOKS (MAP BASE, RIGHT)



AL KAZIMIYAH

AL AIMMAH BRIDGE

Al Azamiyah Mosque

AL AZAMIYAH

KHALID BIN AL WALID EXPRESSWAY

UR

ARMY CANAL

AL QAHIRAH

SAFI AL DIN AL HILLI STREET

FALASTIN (PALESTINE) STREET

AL WAZIRIYAH

AL MUSTANSIRIYAH

SADR CITY

AL IDRISI

Martyrs Monument
The towering memorial was built during Iraq's 1980-1988 war with Iran. Combined casualties topped half a million.

AL UTAYFIYAH

AS SARRAFIYAH BRIDGE

ATH THAWRA STREET

AN NIL

ANCIENT ROUND CITY

Baghdad was founded here in A.D. 762 and fortified by a circular wall.

ASH SHAYKH UMAR

AL MUTANABBI STREET

Al Abbasid Palace

Shahbandar café

Shorjah bazaar

OLD CITY AREA

BUR SAID (PORT SAID) STREET

AR RASHID STREET

AL JUMHURIYAH (KHULAFA) STREET

HAIFA STREET

AL KARAMAH

ASH SHABAB

ARBATASH TAMMUZ (14th of JULY) STREET

TARABULUS

AL KARKH

Iraq Museum

SINAK BRIDGE

TAHRIR SQUARE

Armenian Orthodox Church

AR RUSAFAH

Raiahin Park

ZAYYUNAH

AL JUMHURIYAH BRIDGE

ABU NUWAS STREET

SAADUN STREET

Al Shaab Stadium

AN NIDAL

Firdos Park

Saddam Hussein mosque (unfinished)

Tigris

Palestine Hotel

FIRDOS SQUARE

Baghdad Zoo

Zawra Park

Al Rashid Hotel

INTERNATIONAL ZONE (GREEN ZONE)

Sheraton Ishtar Hotel

Al Alawiyah Club

AL MANSUR

OMAN SQUARE

Festival and Parade Ground

AL KINDI

AL WAHDAH

AL HARITHIYAH

National Theater

Republican Palace

EXPRESSWAY

International Zone
This heavily fortified area, once headquarters of the coalition, holds parliament and other government offices.

Al Salam Palace

U.S. Embassy (under construction)

Al Sijood Presidential Palace

AL AMIRIYAH

AL QADISIYAH

ARBATASH TAMMUZ (14th of JULY) BRIDGE

AL KARRADAH

AZ ZAWIYAH

Lebanese Club

Umm al Khanazir Island

AL JADRIYAH BRIDGE

AL KARRADAH (JAMIA) STREET

BABIL

AD DURAH EXPRESSWAY

AD DURAH BRIDGE

AL JAMIAH

AL QADISIYAH

University of Baghdad

Al Jadriyah Lake Park

AT TAMIM

AL JAZIRAH

AD DURAH

Old City

Built-up area

Dense

Less dense

0 mi 1

0 km 1

Pedestrians navigate Al Jumhuriyah Street, where 12-foot blast walls shield markets on either side. Shoppers skirt the walls and slip between concrete blocks to enter the animal market (at right) and the Shorjah bazaar (at left), where bomb attacks occurred during the years of sectarian conflict.


ANNÜC

CITY OF SORROWS

By the end of 2010 violence had declined by 90 percent from its peak of 240 incidents a day in 2007. Yet episodic bomb blasts continue, such as the one last November that left 20-year-old Fatima Muhassen Aziz (top right) a quadriplegic. Iraqi soldiers (bottom right) and police now receive mandatory training to identify and defuse explosives. Other serious challenges also remain: Nearly one-quarter of Iraqis live below the poverty line of $2.20 a day. Chronic shortages of water, electricity, and fuel have sparked protests. Starting at 6 a.m., women in west Baghdad jostle for kerosene rations (below). Hundreds line up; many leave empty-handed after waiting all day. Says one Baghdad resident: “People wish we were still under Saddam. At least we knew what to expect.”




Dreams
دريمز



Seated near the entrance of the Shahbandar literary café, owner Haji Mohammed al Khashali gazes out to Al Mutanabbi Street, a centuries-old hub for booksellers and intellectuals. A 2007 car bomb near the café killed five of Khashali's sons, whose portraits hang on the wall.

(Continued from page 84) river that doesn't advertise the inexorable pathos transported in its depths. In the winter of A.D. 1258, when the Mongols sacked Baghdad under Hulegu Khan, great destruction was visited upon the city and its inhabitants. The Bayt al Hikma, or House of Wisdom, was plundered, its contents thrown into the Tigris—philosophical tracts and treatises, art, poetry, historical tomes, scientific and mathematical works—the intellectual wealth of centuries. When the Mongols were done pillaging, it's been said, the Tigris ran black with ink.

More recently, it flowed with bodies. In the winter of 2004 soldiers from my battalion manned a johnboat to search an island upriver in the city of Mosul, where a mortar firing position was rumored to be. The boat capsized, and weighed down by their equipment, one soldier and three Iraqi policemen disappeared into the water. My company helped cordon off the riverbanks so that patrol boats and Navy divers could recover their bodies. Before they could find them, the search teams pulled up the bodies of a student from Kirkuk and an Iraqi policeman we weren't even looking for. As I sit in Ismail's water taxi, I'm hesitant to reach over and put my hand into the water. The Tigris has become a kind of graveyard; it deserves respect.

I take a series of photographs. Iraqi Army soldiers materialize from their posts under the bridge abutments and order us to shore. We're briefly detained and questioned by the local commander, who stands in the doorway of a guard shack wearing only a bemused expression and thermal underwear, his combat boots left unlaced, a tiny cup of Arabic coffee in his hand. He orders us not to take any more pictures of the bridges and then releases us. Before we can go, one of the soldiers insists I share from his plate of scrambled eggs. He tears his flatbread in two and shoves a piece into my hands with a smile.

Back out on the Tigris, Ismail tells me there was an incident last week involving a magnetic "sticky" bomb, and that it may also have involved a water taxi. The Iraqi military keeps a vigilant eye on the river. Which makes me wonder how Ismail is able to make a living under such conditions. When were the good times? I ask.

Ismail responds, "Good times?"

Al Mutanabbi Street

A small bird roosts in a cage just outside the door of the Shahbandar café on Al Mutanabbi Street, where poets and philosophers refuse the chessboard for the stimulant of engaging conversation, debate, and intellectual inquiry. As I take a seat beside Mohammed Jawad, a 63-year-old biology professor, I can't help but notice the framed photos of those who died in a 2007 bombing that killed dozens inside and outside the coffee shop. When I ask him about the attack, Jawad says, "The bombings are like the rings on a tree. What do you call them? The growth rings?" I nod as he continues. "Trees experience fire and times of no water. It's a matter of periods. The growth rings show us the good times and the bad times. These are the bad times now, but it's all a part of the growth of the tree." He pauses, sips his chai. "Let me tell you, history is manufactured by war."

Later, as I walk down Al Mutanabbi Street, where tables are stacked with poetry collections and textbooks for sale, I notice the many short, hard glances I'm getting from those going about their business. It's Saturday, around noon, and the street is busy but not packed. Although I hadn't noticed it at first, something inside of me has clicked back into place. I catch myself turning in slow, smooth circles as I walk—I'm scanning the scene behind me to determine if there are any threats. It's a habit I've mostly broken back home in the States. I try to look casual, as if I'm merely curious about the books I've just passed, but in fact I've instinctively reverted back to my days on foot patrol. Whom do I discover trailing me? A poet, who simply wanted to resume a conversation we'd started in the café.

"Of course, I'm a poet," he says. "What else can you do but write poetry in a country like this?"

In Firdos Square the ghost of Saddam Hussein hovers over the pedestal where a statue of him was famously pulled down. So many people here will tell you that although they may have wished for Saddam's removal from power, they miss the

"BAGHDAD IS A HUGE CAMP, MAN. AMERICA DIDN'T BRING DEMOCRACY. IT BROUGHT WALLS."

—YOUSIF AL-TIMIMI



Pilgrims visit Al Kazimiyah Shrine, a Shiite holy site relatively unharmed by the years of violence.

grand vision in which the difficult seemed possible during his reign. After one of the bridges over the Tigris was bombed during the 1991 air campaign of the Gulf War, for example, Saddam vowed that the bridge would be operational within one month. It was an audacious deadline that locals say the construction crews succeeded in meeting. In contrast, the Saddam mosque at the center of the city remains unfinished after more than a decade. Massive concrete columns and rebar rise to impressive heights, while the domes they're meant to support exist only in the architect's blueprints. It was envisioned to be the largest mosque in the Middle East but stands now as a mere sketch of greatness.

The Private Club

Tonight I find myself smoking a *sheesha,* or hookah, loaded up with mint-flavored tobacco, at Al Alawiyah Club near Firdos Square. Swanky. Once past a maze of blast walls and bored security personnel, I sit in a large gazebo near a water fountain lit by blue filtered lights. A well-dressed and sober-faced man smokes his own sheesha two tables over. According to gossip, he's an Iraqi Army general who would rather smoke alone than go home to his wife. I'm told this by Rawaa al-Neaami, the businesswoman who invited me to the club.

Al-Neaami wears jeans tucked into black leather boots, a frilly blouse, and huge earrings. Her hair is cut short and dyed a mixture of colors, mostly reddish hues. She's started a nongovernmental organization in Baghdad to empower young adults. Classes at her school include yoga, dramatic dance, filmmaking, graphic design, and creative writing. "I believe, as a human being, not just as an Iraqi woman, that these skills have a major role in developing students. In fact, they are the soul *(Continued on page 100)*





Vendors prepare *lahm bi ajeen*, similar to pizza, in central Baghdad's bustling, upscale Al Karradah district. Roadside bombs in the neighborhood are a continuing hazard but have not deterred shoppers. Generators help keep lights ablaze during the city's frequent power cuts.





BACK TO LIFE

Baghdad's relative calm has lent sparkle to the city's social scene—especially for the wealthy. At the glitzy new Lebanese Club overlooking the Tigris (top left), patrons must check any weapons at the door before enjoying nonalcoholic drinks on the terrace. Bikers rev their engines in Al Jadriyah Lake Park (bottom left). And young couples feel safe enough to plan for the future. Big weddings costing up to $10,000 have become more common. Some 300 guests celebrated for two days when bride Heelan Muhammad, 23, married Husham Raad, 30, last October. They are saving for a house. Daily life isn't always easy, says 24-year-old Raad Ezat-Khalil (with baby), the groom's cousin and matchmaker, but "the most important thing is how strong and determined people are."







Iraqis escape blistering city temperatures, which can exceed 110°F, in Habbaniyah Lake, 50 miles west of Baghdad. Once a top tourist and honeymoon destination, the Habbaniyah area filled with Sunni refugees fleeing militia violence after the invasion. Tourists have begun trickling back.

“THE BOMBINGS ARE LIKE THE RINGS ON A TREE. WHAT DO YOU CALL THEM? THE GROWTH RINGS?”

—MOHAMMED JAWAD



(Continued from page 93) of our life,” she says. “This is the real jihad. The real jihad doesn’t mean I have to carry a weapon and kill.”

Her latest project, she tells me, involves going into juvenile detention centers in Baghdad to encourage young people through art. She’s been surprised by those she’s discovered there. The inmates range in age from 5 to 18 years old. Many are simply orphans created by the years of sectarian violence. She plans to film a documentary to tell their stories.

The Barbershop

One evening I decide to get a haircut on Al Karradah Street. When I was here as a soldier, three of us once left an abandoned house where we’d set up an observation post to buy a block of ice from a delivery truck. It was August, and we didn’t spot a truck. But on the way back to the house we passed a barbershop, and I mentioned that I could use a haircut.

“You want to get a haircut?” my squad leader asked.

“Sure.”

I don’t know what any of us were thinking, because the security situation in 2004 made sitting in a barbershop with a plate glass window ludicrous. Still, I went inside while my squad leader and grenadier pulled watch out on the sidewalk. The only other customer was an



At the end of a long day a cotton candy vendor awaits customers in Zawra Park, home to an amusement park and the city zoo. The park shuts at 11 p.m., an hour before the nightly curfew empties streets and a new day begins.

out-of-work university professor who spoke excellent English. I propped up my weapon within arm's reach, sat down, and had an amiable conversation with the good professor while the barber worked his trade. So I guess I got what I was really after, a sense of normalcy.

Congenial as our talk was, running through the back of my mind was a wide variety of dangerous scenarios. The plate glass window facing the street was an invitation for all of us to make a small-print, page-18 news column back home. When the barber scraped the bristled hairs on the back of my neck with the flattened edge of a straight razor, I felt alert to every nuance possible within the moment. A subdued but crackling tension seemed to fill the air.

I now sit in a brightly lit and busy barbershop. The atmosphere is relaxed, even cheerful. It's after sundown, and outside, a man with a pushcart kitchen slices thin cuts of meat from a rotisserie for *shawarma,* or flatbread sandwiches. Redolent smoke drifts along the crowded sidewalk. Inside the barbershop, mirrors in front of and behind us create an illusion of multitudes. As the hair falls to the floor below, I'm acutely aware that for some of those present, I'm beginning to look more and more like the soldier I once was.

The New Baghdad

Before leaving Baghdad, I stop in Al Karradah district to buy an Iraqi-made hookah to take back home. Jaywalking through early evening traffic, I notice how energetic street life is. Shop doors are propped open. Upscale fashion retailers feature the latest clothing lines on headless mannequins in glass-front displays. Toy stores, hardware stores, cell phone shops, local grocers—there's a bustle and vibrancy of activity not only among the street vendors but also among the established merchants.

Even so, only yesterday a mortar crew attacked a Shiite gathering in Baghdad, wounding five. A bomb exploded near a mosque in Al Utayfiyah district, injuring three. In Mosul a woman's body was left in the street. When I speak with people here, I recognize years and years of frustration in their voices. And yet, as I look around city neighborhoods, beyond the T-walls and the Hueys patrolling overhead, I also see signs of renewal and growth.

Something has changed within me as well. With each passing day, the adrenaline that accompanied my return to the city has subsided. I can see more clearly now that Baghdad is becoming a new version of itself—not a place defined by war, where journalists and the addicts of danger ply their trades, but a more livable, thriving place. Although it will certainly take time, and the aftermath of war will leave an indelible signature here for the rest of our lives, Baghdad has begun to reimagine itself as a majestic city once more. □

YOUNG, ANGRY, AND WIRED

Armed with cell phones, social media, and sometimes just sheer determination, youth from North Africa to the Middle East are struggling to take ownership of their future.



Citizens observe wreckage in Benghazi after UN-authorized bombing.



New rebel cadets stand at attention in Benghazi.



Leaving Bin Jawwad, rebel soldiers seek cover from gunfire in a truck bed.

It was a generation in waiting. They waited for a good education, and that rarely came. Then they waited for jobs, which paid very little when they did come. Without proper jobs, they waited to get married, often staying with their parents into their 30s—or living with their parents even after they got married. Most important, they waited for liberty: the right to vote freely, to participate in politics, to change the world.

Until they could wait no longer.

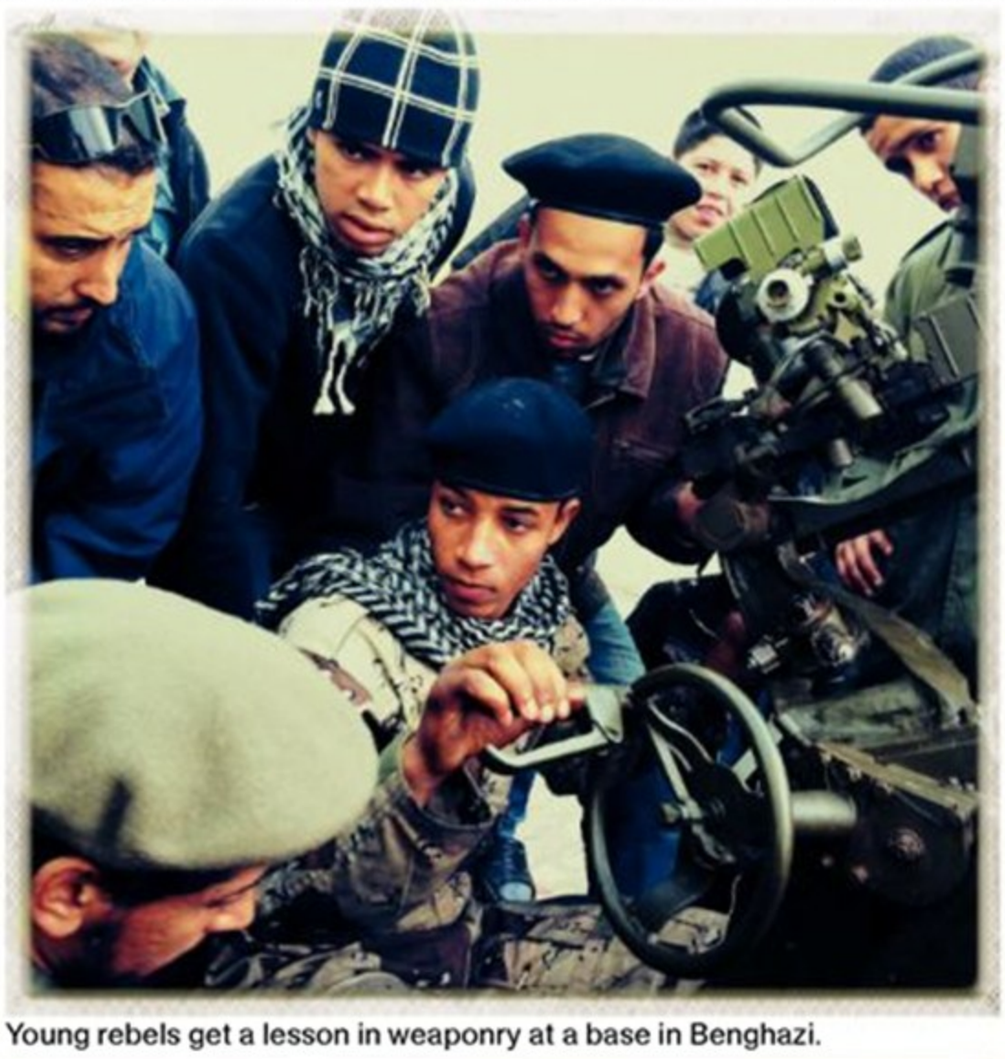
Some 60 percent of the people in the Middle East are under 30 years old, and many of them are angry. Like young people everywhere, they have ambitions. They want, they need, they crave. They feel constrained—especially, perhaps, when they watch satellite television or



A man celebrates at a public burning of Qaddafi's "green book" manifesto.



Protesters gather outside a Benghazi courthouse.



Young rebels get a lesson in weaponry at a base in Benghazi.



Tire tracks and graffiti mark a poster of Libyan leader Muammar Qaddafi.



Soldiers of the rebel army muster on the streets of Benghazi.



Rebels duck bullets during a battle near the town of Bin Jawwad.



Photographer Michael Christopher Brown captured these images on a cell phone with a filter app in February and March of this year.

YOUTH BOOM

More than half the population is under 30, a result of better health care that helped more children survive. In most of the region, birthrates have now fallen, so this boom is peaking.

JOB FRUSTRATION

Bloated bureaucracies that have been the main source of desirable jobs cannot accommodate the youth boom. Private enterprise has lagged, discouraged by complex regulations and political favoritism.

AUTHORITARIAN STATE

Ruling regimes suspend or manipulate constitutional processes. Human rights and press freedom are widely suppressed.

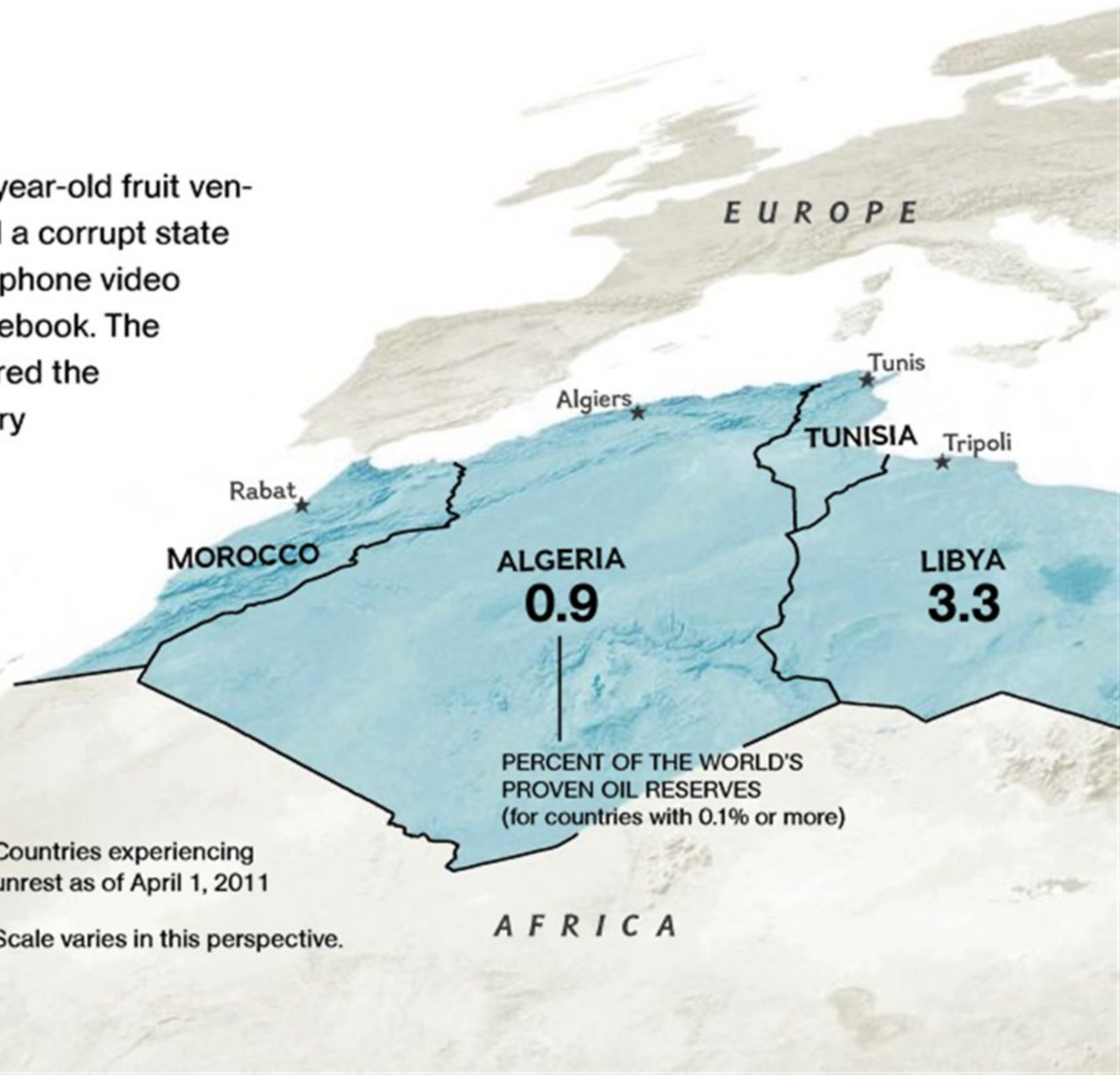
NEW CONNECTIONS

Cell phones are ubiquitous, and a Dubai School of Government study reports that in 2010, Facebook users in the Arab world increased by 78 percent.

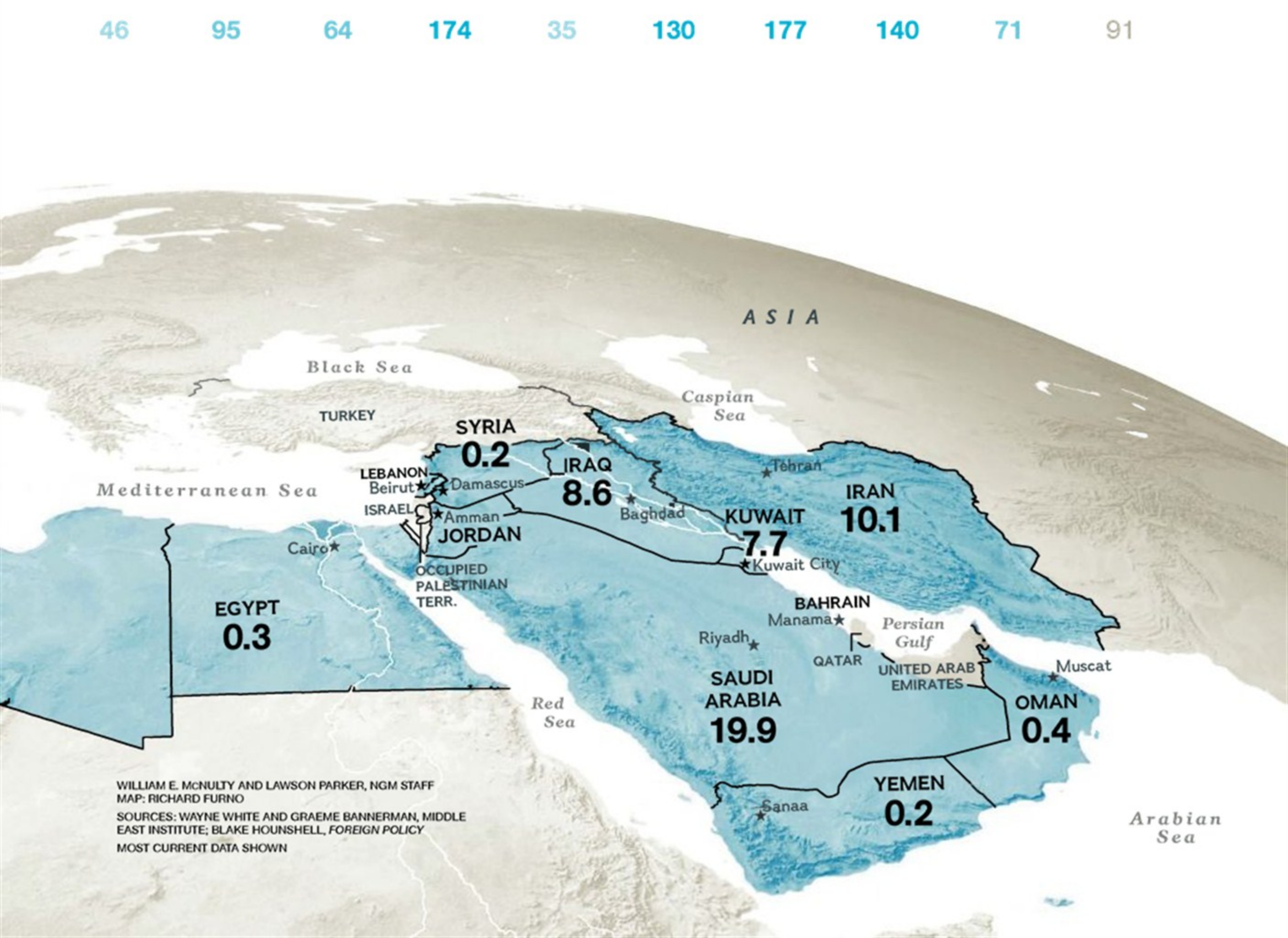
	MOROCCO	ALGERIA	TUNISIA	LIBYA	EGYPT	LEBANON
Population (in millions)	32	35	10.6	6.6	82.1	4.1
Percent under age 30 (SOURCE: U.S. CENSUS BUREAU IDB)	56%	55	50	60	61	50
Percent youth unemployment (ages 15-24) (1 person = 1%; INTERNATIONAL LABOR ORGANIZATION)	22%	24	31	no data	25	22
Economic opportunity (HERITAGE FOUNDATION)	LOW	LOW	LOW	VERY LOW	LOW	MODERATE
Human rights index 0 = least repressive, 10 = most repressive (FUND FOR PEACE)	6.8	7.6	7.5	8.3	8.2	6.8
Cell phone subscriptions (per 100 persons) (UNDP)	79	94	95	149	67	57

DRIVERS OF CHANGE

It started last December in Tunisia. A 26-year-old fruit vendor, humiliated by police harassment and a corrupt state that condoned it, set himself on fire. Cell phone video of protesting vendors was posted on Facebook. The Qatar-based cable network Al Jazeera aired the video. Protests in Tunisia grew. On January 14, Tunisia's president—in office for 23 years—fled. Within a month, Egypt's president since 1981 was also deposed. This cascading push for change has touched almost every country in the region.



	SYRIA	JORDAN	IRAQ	SAUDI ARABIA	YEMEN	KUWAIT	BAHRAIN	OMAN	IRAN	UNITED STATES
	22.5	6.5	30.4	26.1	24.1	2.6	1.2	3	77.9	313.2
	66	64	67	60	73	54	48	63	57	41
	19	27	no data	28	no data	11	20	no data	23	18
	LOW	MODERATE	no data	MODERATE	LOW	MODERATE	HIGH	MODERATE	VERY LOW	HIGH
	8.8	7	9.1	9.1	8	6.5	5.4	6.7	9.4	3.7
	46	95	64	174	35	130	177	140	71	91



WILLIAM E. McNULTY AND LAWSON PARKER, NGM STAFF
MAP: RICHARD FURNO

SOURCES: WAYNE WHITE AND GRAEME BANNERMAN, MIDDLE EAST INSTITUTE; BLAKE HOUNSHELL, *FOREIGN POLICY*

MOST CURRENT DATA SHOWN

surf the Internet. There they can see how the rest of the world lives. Social media (including personal blogs, Facebook, Twitter, YouTube, and more) allow young men and women to share their frustrations in ways they couldn't in the past. They're not alone anymore. Now they have allies. They have power.

Of course, the people of the Middle East are not a singular "them." The Muslim majority of the region includes Arabs, Persians, and Kurds, all of whom speak different languages. Some countries are rich in oil, some are not. Leadership and control vary in brutality and intensity. Syria is a kind of dictatorship; Morocco is a constitutional monarchy. Yemen and Libya are plagued by tribal rivalries; Jordan and Lebanon host large populations of Palestinian refugees; several countries suffer sectarian splits. When anger spills out along these fault lines, it's often destructive.

Navtej Dhillon, a former Brookings Institution fellow who led a project to study youth in the Middle East, spoke presciently in 2008 about the challenges facing the region. The area was simultaneously experiencing an economic and a demographic boom, he said, but young people there felt excluded, suffering unemployment rates nearly twice the world average. Economic and social institutions discouraged the entrepreneurial spirit necessary to build a healthy middle class. "The region faces a scenario of double dividend or double jeopardy," Dhillon explained to staffers of the U.S. Senate Foreign Relations Committee. Leaders in the Middle East could capitalize on the region's youth bulge to create a virtuous cycle of higher growth, higher incomes, and higher savings. Or they could continue to stifle young people's ambitions and experience double jeopardy: lower growth and social strife.

For better and worse, the strife has begun.

—Jeffrey Bartholet

Jeffrey Bartholet is a veteran foreign correspondent and editor who spent a decade reporting from the Middle East. Michael Christopher Brown has photographed three adventure stories for National Geographic. *He is based in New York City.*

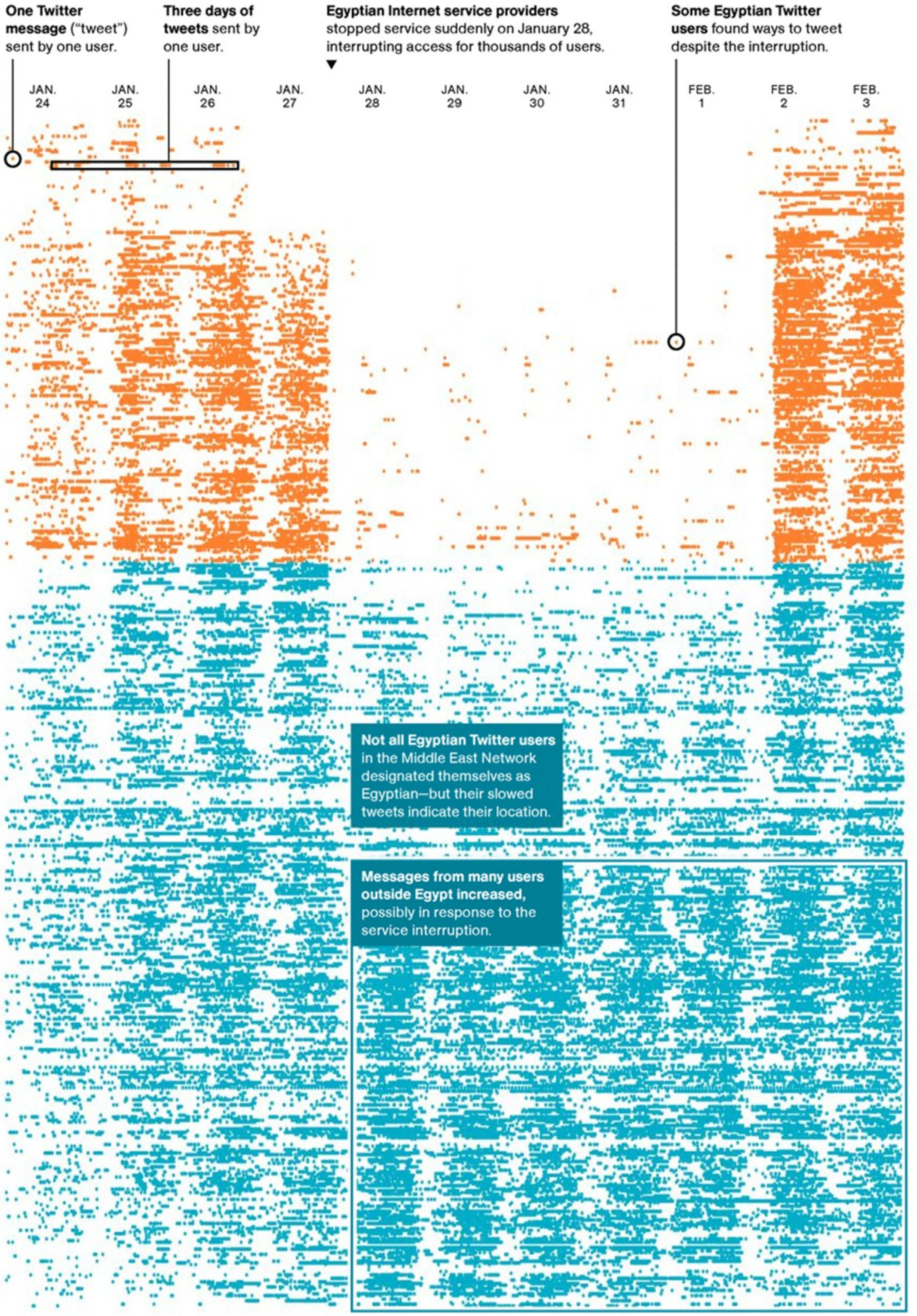
THE FAILED SILENCE

Egyptian President Hosni Mubarak took a drastic step before his ouster: He tried to shut down his country's Internet. In an effort to silence critics, the Mubarak government took major Internet service providers off-line. Data scientist Kovas Boguta created this graphic to show how the cutoff and eventual restoration affected Twitter users in the Middle East. Twitter is a social media service through which brief messages can be relayed to thousands at once. Boguta's sample consists of a selection of Mideast Twitter users who included the keywords (called hashtags) #Jan25 and #Tahrir in messages.



SIGNING UP
Egyptian registration to the social media service HootSuite surged—along with protests in that country—in January.

NGM ART
SOURCES: HOOTSUITE; KOVAS BOGUTA


One Twitter message ("tweet") sent by one user.
Three days of tweets sent by one user.
Egyptian Internet service providers stopped service suddenly on January 28, interrupting access for thousands of users.
Some Egyptian Twitter users found ways to tweet despite the interruption.
JAN. 24
JAN. 25
JAN. 26
JAN. 27
JAN. 28
JAN. 29
JAN. 30
JAN. 31
FEB. 1
FEB. 2
FEB. 3
Not all Egyptian Twitter users in the Middle East Network designated themselves as Egyptian—but their slowed tweets indicate their location.
Messages from many users outside Egypt increased, possibly in response to the service interruption.

FOOD Ark

Conservationist Cary Fowler holds two vials of peas. The sleek structure behind him holds the Svalbard Global Seed Vault, which he founded in Norway to help stop the mass extinction of crops that threatens our future food supply.



A CRISIS IS LOOMING: To feed our growing population, we'll need to double food production. Yet crop yields aren't increasing fast enough, and climate change and new diseases threaten the limited varieties we've come to depend on for food. Luckily we still have the seeds and breeds to ensure our future food supply—but we must take steps to save them.

WILD RELATIVES OF MAIZE AND HERITAGE CORN FROM THE SEED BANK IN AMES, IOWA



GOLD SEBRIGHT

COUNTING ON UNCOMMON CHICKENS

People eat more eggs and poultry than ever, but the world's reliance on a few high-yielding breeds is edging out hundreds of others: Nearly a third of chicken breeds are at risk of extinction. That's alarming because many varieties have traits, like heat or pathogen resistance, that could be invaluable in the future.



LIGHT SUSSEX



BLUE PARTRIDGE BRAHMA



ORPINGTON



DERBYSHIRE REDCAP

CHICKEN BREEDS FROM THE TATTON PARK FARM IN CHESHIRE, ENGLAND



BLUE PARTRIDGE BRAHMA



SILVER GRAY DORKING



HAMBURGH BANTAM



PEKIN BANTAM



SPECKLED SUSSEX



BLACK SILKIE



PHOENIX

SEVEN BILLION SPECIAL SERIES

BY CHARLES SIEBERT

PHOTOGRAPHS BY JIM RICHARDSON

SIX MILES OUTSIDE the town of Decorah, Iowa, an 890-acre stretch of rolling fields and woods called Heritage Farm is letting its crops go to seed. It seems counterintuitive, but then everything about this farm stands in stark contrast to the surrounding acres of neatly rowed corn and soybean fields that typify modern agriculture. Heritage Farm is devoted to collecting rather than growing seeds. It is home to the Seed Savers Exchange, one of the largest nongovernment-owned seed banks in the United States.

In 1975 Diane Ott Whealy was bequeathed the seedlings of two heirloom plant varieties that her great grandfather had brought to America from Bavaria in 1870: Grandpa Ott's morning glory and his German Pink tomato. Wanting to preserve such unique varieties, Diane and her husband, Kent, decided to establish a place where people could store and trade the seeds of their own past. The exchange now has more than 13,000 members and keeps in its walk-in coolers, freezers, and root cellars the seeds of many thousands of heirloom varieties. The farm grows a glorious profusion of select vegetables, herbs, and flowers around an old red barn that is covered in Grandpa Ott's stunningly deep purple morning glory blossoms.

"Each year our members list their seeds in this," Diane Ott Whealy says, handing over a copy of the *Seed Savers Exchange 2010 Yearbook.* It is as thick as a big-city telephone directory, with page after page of exotic beans, garlic, potatoes, peppers, apples, pears, and plums—each with its own name, personal history, and distinct essence. There's an apple known as Beautiful Arcade, a "yellow fruit splashed with red"; one named Prairie Spy, described as "precocious"; another dubbed Sops of Wine that dates back to the Middle Ages. There's an Estonian Yellow Cherry tomato obtained from "an elderly Russian lady" in Tallinn, a bean found by archaeologists searching



Wind does the work for farmers on the Loess Plateau in Shaanxi Province, China. They toss millet into the air; gusts separate the grains from their husks. Farmers like these men still produce most of the world's food.

SEVEN BILLION is a yearlong series on global population.



for pygmy elephant fossils in New Mexico, a Persian Star garlic from "a bazaar in Samarkand."

Heirloom vegetables have become fashionable in the United States and Europe over the past decade, prized by a food movement that emphasizes eating locally and preserving the flavor and uniqueness of heirloom varieties. Found mostly in farmers markets and boutique groceries, heirloom varieties have been squeezed out of supermarkets in favor of modern single-variety fruits and vegetables bred to ship well and have a uniform appearance, not to enhance flavor. But the movement to preserve heirloom varieties goes way beyond America's renewed romance with tasty, locally grown food and countless varieties of tomatoes. It's also a campaign to protect the world's future food supply.

Most of us in the well-fed world give little thought to where our food comes from or how it's grown. We steer our shopping carts down supermarket aisles without realizing that the apparent bounty is a shiny stage set held up by increasingly shaky scaffolding. We've been hearing for some time about the loss of flora and fauna in our rain forests. Very little, by contrast, is being said or done about the parallel erosion in the genetic diversity of the foods we eat.

Food varieties extinction is happening all over the world—and it's happening fast. In the United States an estimated 90 percent of our

historic fruit and vegetable varieties have vanished. Of the 7,000 apple varieties that were grown in the 1800s, fewer than a hundred remain. In the Philippines thousands of varieties of rice once thrived; now only up to a hundred are grown there. In China 90 percent of the wheat varieties cultivated just a century ago have disappeared. Experts estimate that we have lost more than half of the world's food varieties over the past century. As for the 8,000 known livestock breeds, 1,600 are endangered or already extinct.

Why is this a problem? Because if disease or future climate change decimates one of the handful of plants and animals we've come to depend on to feed our growing planet, we might desperately need one of those varieties we've let go extinct. The precipitous loss of the world's wheat diversity is a particular cause for concern. One of wheat's oldest adversaries, *Puccinia graminis,* a fungus known as stem rust, is spreading across the globe. The pestilence's current incarnation is a virulent and fast-mutating strain dubbed Ug99 because it was first identified in Uganda in 1999. It then spread to Kenya, Ethiopia, Sudan, and Yemen. By 2007 it had jumped the Persian Gulf into Iran. Scientists predict that Ug99 will soon make its way into the breadbaskets of India and Pakistan, then infiltrate Russia, China, and—with a mere hitch of a spore on an airplane passenger's shoe—our hemisphere as well.

Roughly 90 percent of the world's wheat is defenseless against Ug99. Were the fungus to come to the U.S., an estimated one billion dollars' worth of wheat would be at risk. Scientists project that in Asia and Africa alone the portion of wheat in imminent danger would leave one billion people without their primary food source. A significant humanitarian crisis is inevitable, according to Rick Ward of the Durable Rust Resistance in Wheat project at Cornell University.

The world's population is expected to reach seven billion people this year. By 2045 it could grow to nine billion. Some experts say we'll need to double our food production to keep up with demand as emerging economies consume more meat and dairy. Given the added challenges posed by climate change and constantly mutating diseases like Ug99, it is becoming ever more urgent to find ways to increase food yield without exacerbating the genetic anemia coursing through industrialized agriculture's ostensible abundance. The world has become increasingly dependent upon technology-driven, one-size-fits-all solutions to its problems. Yet the best hope for securing food's future may depend on our ability to preserve the locally cultivated foods of the past.

IT TOOK MORE THAN 10,000 YEARS of domestication for humans to create the vast biodiversity in our food supply that we're now watching ebb away. Selectively breeding a wild plant or animal species for certain desirable traits began as a fitful process of trial and error motivated by that age-old imperative: hunger. Wild wheat, for example, drops its ripened kernels to the ground, or shatters, so that the plant can reseed itself. Early farmers selected out wheat that, due to a random genetic mutation, didn't shatter and was thus ideal for harvesting.

Farmers and breeders painstakingly developed livestock breeds and food crops well suited to the peculiarities of their local climate and environment. Each domesticated seed or breed was an answer to some very specific problem—such as drought or disease—in a very specific place. The North American Gulf Coast Native sheep, for example, thrives in high heat and humidity and has broad parasite resistance. On the remote Orkney Islands, North Ronaldsay sheep can live on nothing but seaweed. Zebu cattle are more resistant to ticks than other cattle. In Ethiopia a small, humpless, shorthorned cattle breed called the Sheko is a good milk producer that withstands harsh conditions and has resistance to sleeping sickness.

Such adaptive traits are invaluable not only to local farmers but also to commercial breeders elsewhere in the world. Finnsheep, for example, long raised only by a small group of Finnish

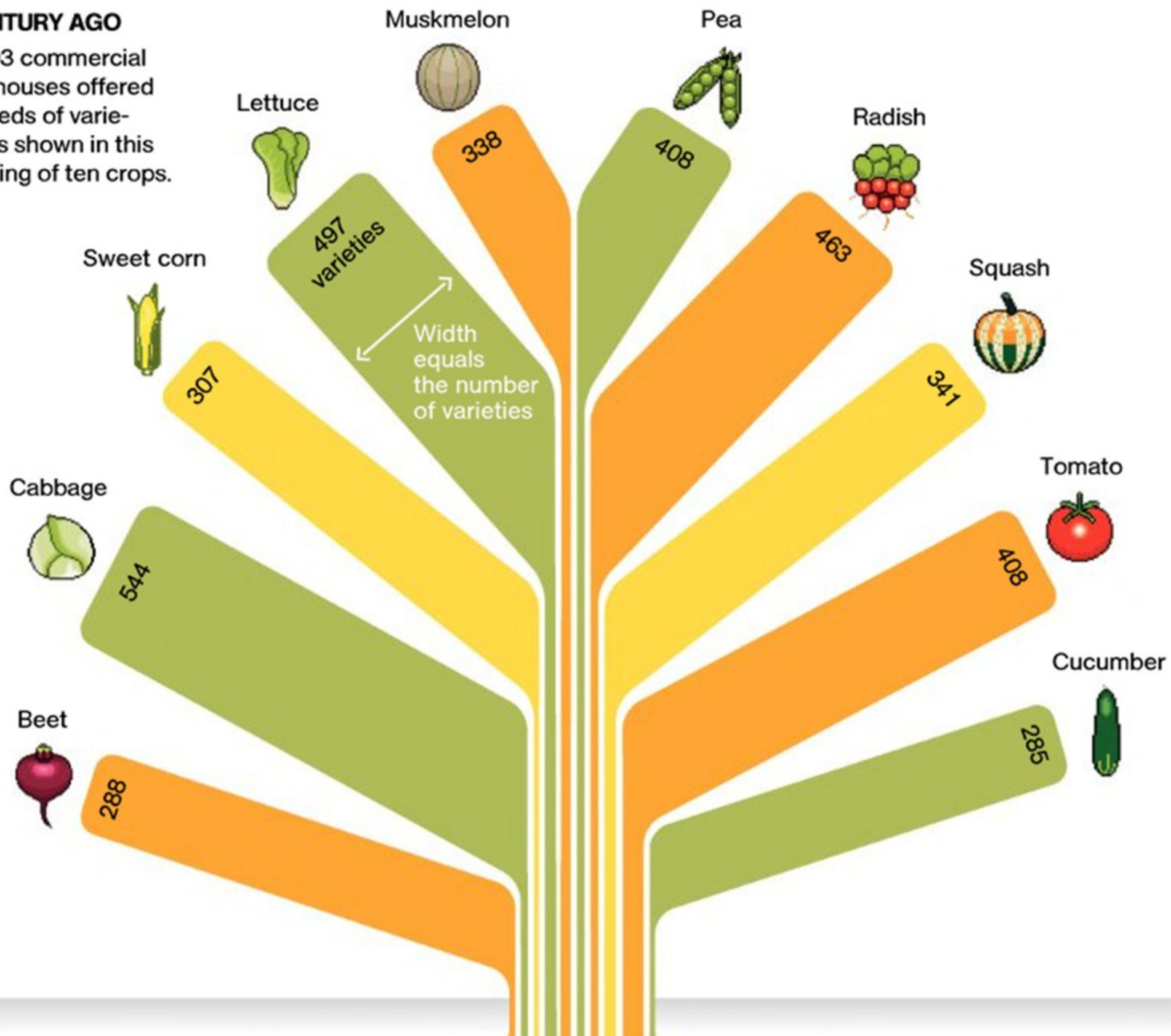
Charles Siebert is the author of The Wauchula Woods Accord: Toward a New Understanding of Animals. *Jim Richardson documented the importance of soil to our food supply in the September 2008 issue.*

OUR DWINDLING FOOD VARIETY

As we've come to depend on a handful of commercial varieties of fruits and vegetables, thousands of heirloom varieties have disappeared. It's hard to know exactly how many have been lost over the past century, but a study conducted in 1983 by the Rural Advancement Foundation International gave a clue to the scope of the problem. It compared USDA listings of seed varieties sold by commercial U.S. seed houses in 1903 with those in the U.S. National Seed Storage Laboratory in 1983. The survey, which included 66 crops, found that about 93 percent of the varieties had gone extinct. More up-to-date studies are needed.

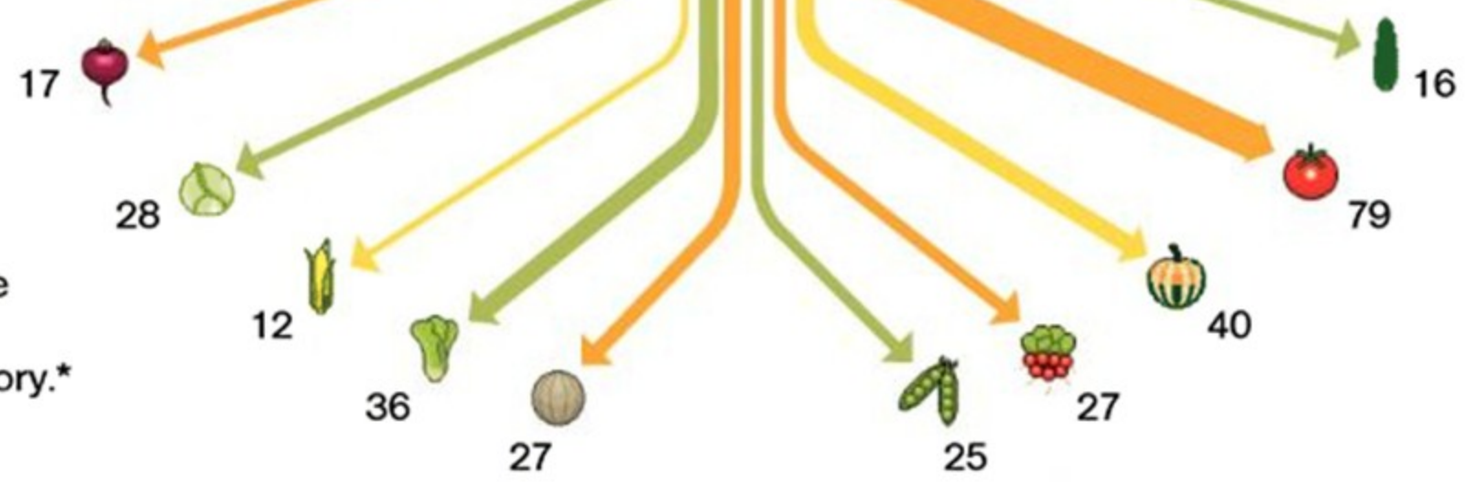
A CENTURY AGO

In 1903 commercial seed houses offered hundreds of varieties, as shown in this sampling of ten crops.



80 YEARS LATER

By 1983 few of those varieties were found in the National Seed Storage Laboratory.*



*CHANGED ITS NAME IN 2001 TO THE NATIONAL CENTER FOR GENETIC RESOURCES PRESERVATION.

JOHN TOMANIO, NGM STAFF. FOOD ICONS: QUICKHONEY
SOURCE: RURAL ADVANCEMENT FOUNDATION INTERNATIONAL

peasants, have become vital to the sheep industry because of their ability to produce large litters. The Fayoumi chicken, an indigenous Egyptian species dating back to the reign of the pharaohs, is in great demand as a prodigious egg layer with high heat tolerance and resistance to numerous diseases. Similarly, the rare Taihu pig of China is coveted by the world's pig breeders for its ability to thrive on cheap forage foods and its unusual fertility, regularly producing litters of 16 piglets as opposed to an average of 10 for Western breeds.

The irony is that the dangerous dwindling of diversity in our food supply is the unanticipated result of an agricultural triumph. The story is well-known. A 30-year-old plant pathologist named Norman Borlaug traveled to Mexico in 1944 to help fight a stem rust epidemic that had caused widespread famine. Crossing different wheat varieties from all over the world, he arrived at a rust-resistant, high-yield hybrid that helped India and Pakistan nearly double their wheat production—and saved a billion people from starvation. This so-called green revolution helped introduce modern industrialized agriculture to the developing world.

But the green revolution was a mixed blessing. Over time farmers came to rely heavily on broadly adapted, high-yield crops to the exclusion of varieties adapted to local conditions. Monocropping vast fields with the same genetically uniform seeds helps boost yield and meet immediate hunger needs. Yet high-yield varieties are also genetically weaker crops that require expensive chemical fertilizers and toxic pesticides. The same holds true for high-yield livestock breeds, which often require expensive feed and medicinal care to survive in foreign climates. The drive to increase production is pushing out local varieties, diluting livestock's genetic diversity in the process. As a result, the world's food supply has become largely dependent on a shrinking list of breeds designed for maximum yield: the Rhode Island Red chicken, the Large White pig, the Holstein cow. In short, in our focus on increasing the amount of food we produce today, we have accidentally put ourselves at risk for food shortages in the future.



Relying on a small number of food crops is risky, as Irish farmers discovered when the Lumper potato succumbed to blight, resulting in the great Irish potato famine that began in 1845 (memorialized in Dublin above).



One cautionary tale about the perils of relying on a homogenous food source revolves around the humble potato. High in the Peruvian Andes, where the potato was first domesticated, farmers still grow thousands of otherworldly looking varieties. Spanish ships in the late 16th century first brought the tuber to Europe, where by the early 1800s it had become a reliable backup to cereal crops, particularly in the cold, rain-soaked soils of Ireland. The Irish were soon almost wholly dependent on the potato as their food staple. And they were planting primarily one prodigious variety, the Lumper potato, whose genetic frailty would be cruelly exposed by *Phytophthora infestans,* as fearsome a foe of potatoes as stem rust is of wheat. In 1845 spores of the deadly fungus began spreading across the country, destroying nearly all the Lumpers in its path. The resulting famine killed or displaced millions.

Current efforts to increase food production in the developing world—especially in Africa, largely bypassed by the green revolution—may only accelerate the pace at which livestock breeds and crop species disappear in the years to come. In pockets of Africa where high-yield seeds and breeds have been introduced, the results have been mixed at best. Countries like Zimbabwe, Zambia, and Malawi ended up sacrificing much of their crop diversity to the monocropping of imported, high-yield varieties subsidized by



Andean potato farmers have long known how to hedge against climate fluctuations and the sudden plagues that can afflict fields that have just one variety: Plant hundreds of varieties over many fields in different locations. Mariano Sutta Apucusi (reclining) and his family take a break from harvesting potatoes in Pampallacta, Peru.





All the food crops we eat today were developed and diversified about 10,000 years ago in these relatively few regions, first identified by the great Russian botanist Nikolay Vavilov in the early 20th century.

government programs and provided by aid organizations. Small farmers and pastoralists have gone deep into debt to pay for the "inputs"—the fertilizers, pesticides, high-protein feeds, and medication—required to grow these new plants and livestock in different climate conditions. They are like addicts, hooked on a habit they can ill afford in either economic and ecological terms.

ONE RESPONSE to the rapidly dwindling biodiversity in our fields has been to gather and safely store the seeds of as many different crop varieties as we can before they disappear forever. It's an idea first conceived by Russian botanist Nikolay Vavilov, who in 1926 had perhaps the least heralded scientific epiphany of the modern era. The son of a Moscow merchant who'd grown up in a poor rural village plagued by recurring crop failures and food rationing, Vavilov was obsessed from an early age with ending famine in both his native Russia and the world. In the 1920s and '30s he devoted himself to gathering seeds on five continents from the wild relatives and unknown varieties of the crops we eat, in order to preserve genes that confer such essential characteristics as disease and pest resistance and the ability to withstand extreme climate conditions. He also headed an institute (now called the Research Institute of Plant Industry, in St. Petersburg) tasked with preserving his burgeoning collection—what amounted to the first global seed bank.

It was on one expedition to Abyssinia (now Ethiopia) in 1926 that Vavilov had a vision in which he attained a vantage point high enough above the planet to see the handful of locations across the Earth where the wild relatives of our food crops had first been domesticated. Afterward he mapped out seven "centers of origin of cultivated plants," which he described as the ancient birthing grounds of agriculture. "It is possible to witness there," Vavilov wrote, "the great role played by man in the selection of the cultivated forms best suited to each area."

Vavilov's life story did not end happily. In 1943 one of the world's foremost authorities on the potential cures for famine died of starvation in a prison camp on the Volga River, a victim of Stalin, who had deemed Vavilov's seed-gathering efforts bourgeois science. By this time, Hitler's army had already closed in on St. Petersburg (then Leningrad)—a desperate city that had lost more than 700,000 people to hunger and disease. The Soviets had ordered the evacuation of art from the Hermitage, convinced that Hitler had his sights set on the museum. They had done nothing, however, to safeguard the 400,000 seeds, roots, and fruits stored in the world's largest seed bank. So a group of scientists at the Vavilov Institute boxed up a cross section of seeds, moved them to the basement, and took shifts protecting them. Historical documents later revealed that Hitler had, in fact, established a

LISA R. RITTER, NGM STAFF. SOURCE: N. I. VAVILOV, *ORIGIN AND GEOGRAPHY OF CULTIVATED PLANTS*



STRONG MORNING FROST



ASHES OF THE SOUL



BLACK CAP

THAT'S A POTATO?

Unlike the handful of varieties in U.S. markets, potatoes in Peru and Bolivia—the species' geographic center of origin—come in thousands of colors and shapes. They are so varied in flavor and nutrition that a whole diet can be built around them.



BLACK-AND-WHITE SPIRAL



BLUE



GUINEA PIG FETUS



YELLOW FLOWER



SACRED MOUNTAIN



WHIP MADE OF DRY ANIMAL SKIN



FIG



HIGH-ALTITUDE FLOWER



BLACK SWEET



FEET OF THE LEQUECHO BIRD



MAKES THE DAUGHTER-IN-LAW CRY



PUMA'S PAW



PORK DISH



HIGH MOUNTAIN VILLAGE



WOVEN VEST

Hill Radnor sheep leap out to pasture in the Brecon Beacons region of Wales. Such hardy traditional breeds fare better in hilly terrain than higher-yielding commercial breeds—and don't require expensive feeds.



commando unit to seize the seed bank, perhaps hoping to one day control the world's food supply.

Although suffering from hunger, the seeds' caretakers refused to eat what they saw as their country's future. Indeed, by the end of the siege in the spring of 1944, nine of the institute's self-appointed seed guardians had died of starvation.

Vavilov's ideas have been modified in the years since. Today's scientists consider the regions he mapped to be centers of diversity rather than of origin, because it isn't clear whether the earliest domestication occurred there first. Yet Vavilov's vision of these regions as the repositories of the genetic diversity upon which the future of our food depends is proving more prescient than ever.

Today there are some 1,400 seed banks around the world. The most ambitious is the new Svalbard Global Seed Vault, set inside the permafrost of a sandstone mountain on the Norwegian island of Spitsbergen just 700 miles from the North Pole. Started by Cary Fowler in conjunction with the Consultative Group on International Agricultural Research, the so-called doomsday vault is a back-up for all the world's other seed banks. Copies of their collections are stored in a permanently chilled, earthquake-free zone 400 feet above sea level, ensuring that the seeds will remain high and dry even if the polar ice caps melt.

Fowler's Global Crop Diversity Trust recently announced what amounts to a recapitulation of Vavilov's worldwide seed-gathering expeditions: a ten-year initiative to scour the Earth for the last remaining wild relatives of wheat, rice, barley, lentils, and chickpeas in order to "arm agriculture against climate change." The hope is that this mad-dash scramble will allow scientists to pass along the vital traits of these rugged relatives, such as drought and flood tolerance, to our vulnerable crop varieties.

Still, storing seeds in banks to bail us out of future calamities is only a halfway measure. Equally worthy of saving is the hard-earned

SUSTAINABLE BEEF Rare-breed advocates say the best way to preserve vulnerable cattle is to keep them in the food chain, producing milk or meat. Their motto: "To save them we've got to eat them."

MILKING DEVON
This hardy, multipurpose American breed is adapted to survive in extreme weather, even on a low-quality, high-forage diet.

ZEBU
Also known as Humped or Brahman, this breed is relied on by farmers in the tropics because it can withstand severe heat.

PINEYWOODS
True survivors, these cattle are small and rugged and can live and breed without human assistance.



MONTAGE ASSEMBLED FROM SEPARATE PHOTOGRAPHS TAKEN AT THE SEDGWICK COUNTY ZOO, IN WICHITA, KANSAS

wisdom of the world's farmers, generations of whom crafted the seeds and breeds we now so covet. Perhaps the most precious and endangered resource is the knowledge stored in farmers' minds.

FORTY-YEAR-OLD Jemal Mohammed owns a five-acre, hillside farm outside the tiny hamlet of Fontanina in the Welo region of Ethiopia's northern highlands. It is in the heart of one of the centers of diversity that Nikolay Vavilov visited on his 1926 expedition.

Stepping foot on Mohammed's land is like tumbling back in time to an ancient way of farming. His circular, thatched-roof hut with walls of dried mud and straw is the same dwelling that has dotted Ethiopia's countryside for centuries. A pair of oxen lies to the right of the hut in the shade of a jacaranda tree. Three or four chickens strut across a bare front yard. His fields, tilled with an ox-drawn plough and planted by hand, are a jumble of crops: tomatoes, onions, garlic, cilantro, gourds, sorghum, wheat, barley, chickpeas, and teff, a grain used to make injera, a flatbread.

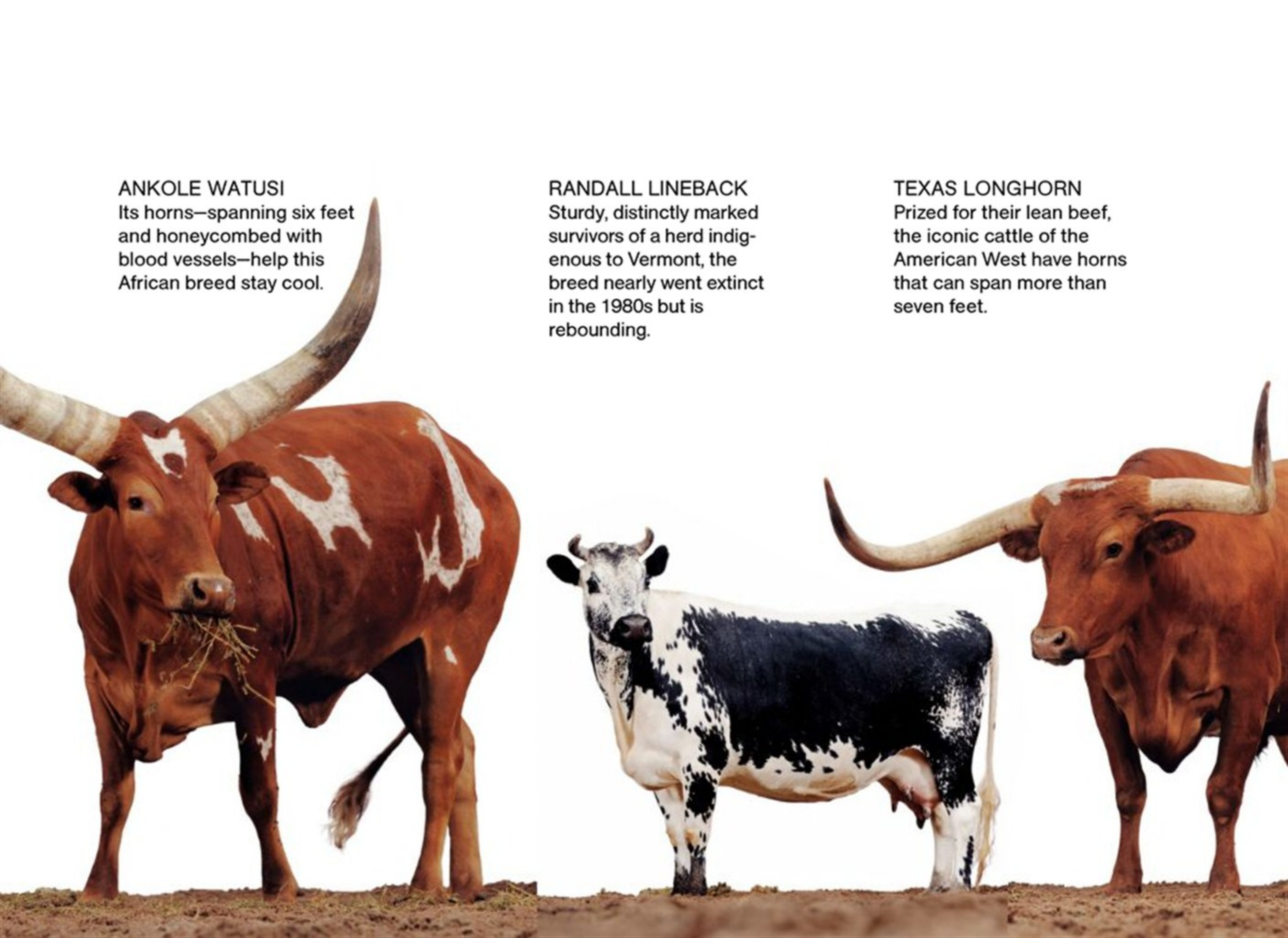
The image of the traditional, small farmer's life is one of simplicity. And yet compared with the mechanized operations of modern agriculture, Mohammed's work is a dynamic and highly nuanced juggling act in the face of constant threats like drought, untimely downpours, and disease. He plants legumes and grain together to make the most of limited space. Such intercropping is also a natural way of fertilizing: The legumes growing at the base of the taller sorghum add nitrogen to the soil.

Welo was one of the regions hit hardest by the devastating 1984 famine in Ethiopia that killed hundreds of thousands. The experience is still seared in Mohammed's memory. He shows me a collection of hollowed-out gourds filled to the brim with what look to be colored pebbles. "I keep these stocks as my security, my backup," he says, looking

ANKOLE WATUSI
Its horns—spanning six feet and honeycombed with blood vessels—help this African breed stay cool.

RANDALL LINEBACK
Sturdy, distinctly marked survivors of a herd indigenous to Vermont, the breed nearly went extinct in the 1980s but is rebounding.

TEXAS LONGHORN
Prized for their lean beef, the iconic cattle of the American West have horns that can span more than seven feet.



down at the gourd casks filled with what I now realize are seeds. He has seeds for all of the crops growing in his fields. Mohammed's wife has rubbed the seeds in ash to protect them from weevils. "If we have total crop failure from drought or floods," he says, "I can at least plant my fields again."

I look into the intent faces of Mohammed and his family, then down at those ashen pebbles: all incipience, gnarled knots of built-in urge, suggesting neither the centuries of selection that informed them nor the full-fleshed foods they'll eventually become, his own personal seed bank.

This is the beguiling paradox of seeds. They are, for all their obvious significance, so readily dismissible, especially by those of us in the well-fed world, who have forgotten where our food even comes from. Mohammed takes me to a farm across the road, where he and his neighbor lift a stone slab to reveal an earthen chamber six feet deep and wide: an emergency underground food store. In a few weeks, when the harvest is complete, they will line the chamber with straw, fill it with grain, and then pull the slab back over, allowing the earth's chill to keep it fresh.

When I ask how much they had to rely on their emergency store during the famine of 1984, they bow their heads and mumble a response before falling completely silent, their eyes welling with tears. My interpreter signals with a wave of a finger not to pursue the subject any further.

It is hard for them to even think of that time, he explains. They had sold their stored grain, never anticipating a sudden drought. Things got so bad that they had to eat all their reserves. A number of family members died of starvation. They were left with nothing but their seeds. Conditions were so inhospitable to planting that their empty stomachs soon had them planning to do the unthinkable: eat their seeds, their future.

ETHIOPIA'S EAST CENTRAL HIGHLANDS were once one of most botanically diverse spots on Earth, but by the 1970s farmers here were down to growing just teff and a few varieties of wheat distributed to them for its high-yield potential. Today the region has been transformed: Local varieties of legumes and wheat are thriving again. Given the common depiction of Ethiopia as famine prone, it is startling to drive an hour northeast of Addis Ababa and see ample fields of a bushy, purple-seeded durum wheat, a variety found only in Ethiopia that is thriving across the country. Used for pasta, durum is largely resistant to stem rust. In one field is another local variety native to Ethiopia known as *setakuri,* which translates as "pride of women," because it makes the sweetest bread. It is doing even better against stem rust.

Ethiopia's turnaround can be traced in part to the efforts of renowned plant geneticist Melaku Worede, who received his Ph.D. from the University of Nebraska in 1972, then returned to Ethiopia with the goal of preserving—and rebuilding—the country's rich biodiversity. Training a new generation of plant breeders and geneticists, Worede and his staff at the Plant Genetic Resources Centre in Addis Ababa set about collecting and storing native plants and seeds, known as landraces, from across the country. In 1989 Worede initiated the Seeds of Survival program, a network of community seed banks that save and redistribute the seeds of local farmers.

Worede is hopeful that new efforts to increase food production—such as the Gates Foundation's Alliance for a Green Revolution in Africa—will not repeat the mistakes of the past. Attempts are being made to include local farmers in decision-making. "The people planning this are aware that the first green revolution failed over time. There are some intelligent ideas," Worede says. "But they are still placing too much emphasis on a narrow range of varieties. What about the rest? We'll lose them. Believe me, I'm not against science. Why would I be? I'm a scientist. But contextualize it. Combine science with the local knowledge, the farmer's science."

Worede believes it is crucial to preserve the region's diversity not just in seed banks but on the ground and in close consultation with local farmers. Although yield is obviously important to farmers, even more crucial is hedging their bets against famine, spreading the risk by growing many crops, over many seasons, in many locations. In this way if one crop gets diseased, or



NEW GUINEA ROSEWOOD



DEVIL'S CLAW



ARGENTINE SCREWBEAN

SEEDS WORTH SAVING

Otherworldly seeds (and their pods) are as varied as the plants they become. Agriculture isn't just about growing food; it includes trees and other plants that produce fiber, control wind erosion, and shade livestock.



SACRED LOTUS



EARLEAF ACACIA



LOOKING-GLASS MANGROVE



AUSTRALIAN PINE



SEA MANGO



KIAAT



TEXAS MOUNTAIN LAUREL



AFRICAN MAHOGANY



JAVA COTTON



ZEYHERI



TIPU



WOODY PEAR



FLAME OF THE FOREST



TRAVELERS PALM



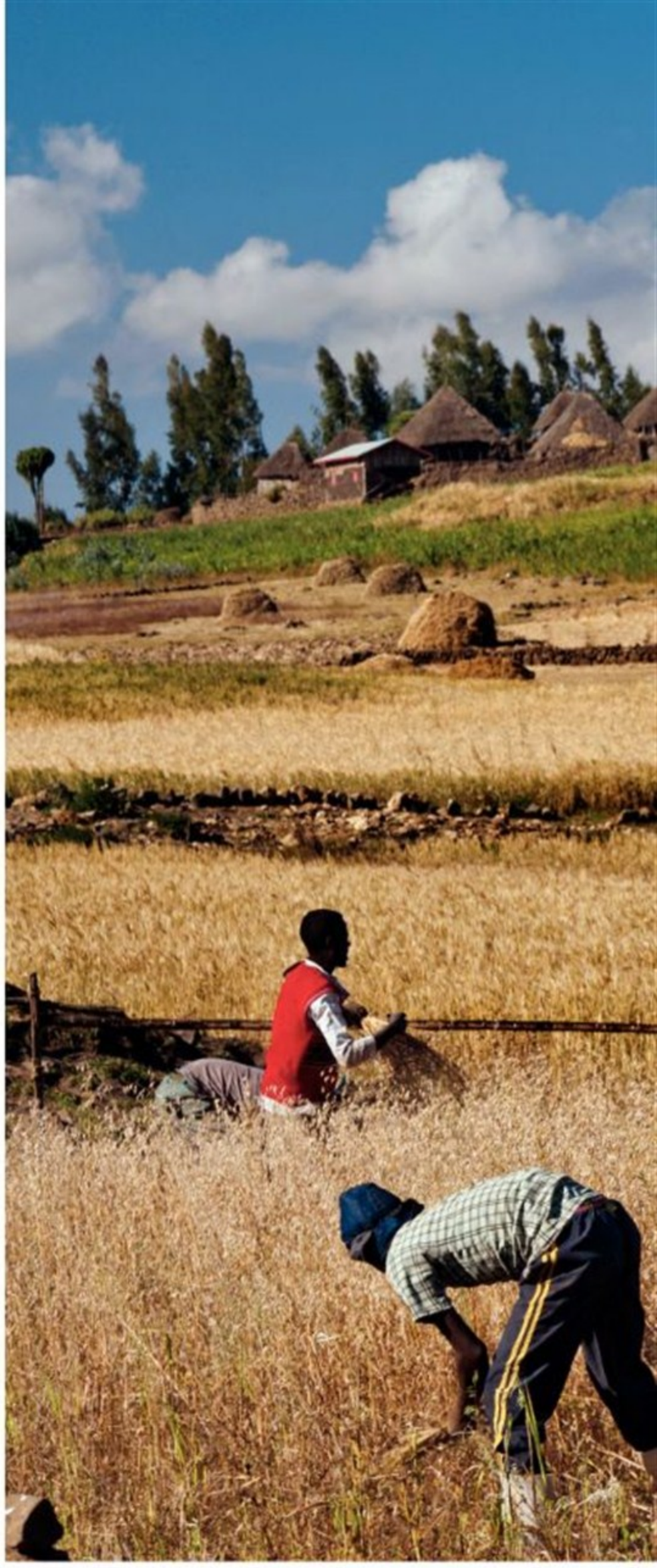
WEST INDIAN MAHOGANY

one harvest succumbs to drought, or one hillside is flooded, they have alternatives to fall back on.

The challenge has been to show it's possible to increase productivity without sacrificing diversity. Worede wanted to prove that deciding between having enough to eat today and preserving food biodiversity for tomorrow is a false choice. And he has done precisely that. He has taken the varieties farmers selected for their adaptability and determined which of them promise the best yield. The use of high-yielding local seeds—in combination with natural fertilizers and techniques such as intercropping—has improved yield as much as 15 percent above that of the imported, high-input varieties. A parallel effort is under way with local indigenous livestock breeds. Keith Hammond, a UN expert on animal genetics, says that in 80 percent of the world's rural areas the locally adapted genetic resources are superior to imported breeds.

Still, a 15 percent increase is far from the doubling of our food supply experts say we'll need in future decades. Preserving food diversity is only one of many strategies we'll need to meet that challenge, but it is a crucial one. As the world warms, and the environment becomes less hospitable to the breeds and seeds we now rely on for food, humanity will likely need the genes that allow plants and animals to flourish in, say, the African heat or in the face of recurring blight. Indeed, Worede thinks scientists may well find the Ug99-resistant varieties they're looking for in Ethiopia's fields. "Even if the disease mutates into a new form, it will not wipe out everything here. That is the advantage of diversity."

Yet Worede balks at the idea of the developed world treating Vavilov centers like Ethiopia as wild seed banks from which to withdraw traits whenever the next plague strikes. He cites the outbreak in the early 1970s of yellow dwarf virus, which threatened to wipe out the world's barley crop. A U.S. scientist who had come to Ethiopia in the 1960s had happened to grab some barley samples from a field for his own study. When the virus hit, he handed over the samples to one of the scientists trying to stop the virus. Sure enough they found a resistant gene. "It changed everything,"



On a hillside farm northeast of Addis Ababa, Ethiopia, farmers harvest oats with sickles, then stack it in piles. They may use low-tech tools, but their knowledge is key to producing enough food to feed a growing planet.

says Worede, "at no cost to them. No genetic engineering, nothing. Just a natural source of resistance taken from the very part of Ethiopia where people were suffering from starvation."

Mohammed and his neighbor stood in silence above their own private earthen seed bank that afternoon in Welo. Since the famine of 1984, they don't even think of selling any grain until they know what the harvest has brought. I asked whether the bounty I'd seen in their fields had them feeling a bit more secure and optimistic.

"It will be nice to have some extra money," Mohammed began, "so we can send our kids to school in good clothes, but…" He paused, looking over at his neighbor, then gave an answer I've come to think might perfectly describe the attitude we all should adopt when it comes to securing our future food supply.

"We're positive," Mohammed said. "But we're very sensitive to risk." ▯



SEVEN BILLION IN SEPTEMBER
What's one of the best ways to lower fertility rates around the globe? Just ask the women of Brazil.

The Pulitzer Center on Crisis Reporting and PBS NewsHour *join us in reporting on population issues throughout the year.*

The magazine thanks the David and Lucile Packard Foundation, the Wallace Global Fund, and National Geographic Society members for their generous support of this series of articles.

INSET: JOHN STANMEYER

The Delicate Balance of Portugal's Premier Park

A blend of wilderness and civilization, Portugal's Peneda-Gerês National Park faces a tricky challenge: protecting nature while accommodating people.

Matted with mosses and hairy with epiphytes, an oak forest flourishes in the Homem Valley. Three climate zones influence weather in Peneda-Gerês, which encompasses a mosaic of natural habitats, from stony summits to verdant valleys.



BY TOM MUELLER

PHOTOGRAPHS BY PETER ESSICK

At nightfall, biologist Francisco Álvares walks through the village of Pitões das Júnias, in northern Portugal, greeting old friends. Two women in widow's black touch his arm sociably as he passes the street corner where they sit singing folk songs to each other. He nods to a pretty blond teenager who has just penned up her father's 200 goats for the night, and exchanges gibes with a cowhand driving his long-horned cattle home from the fields.

At the edge of town he stops and looks westward, where patchwork fields melt into dense oak forest, then rise into sharp granite peaks. He cups his hands over his mouth, draws a breath, and makes a low, lonesome moan that rises to a fierce cry. The only reply is the wind soughing in the oaks and the occasional clonk of a cowbell. He calls twice more. Finally an answer comes, surprisingly close and loud, the same sad sound rising to exultation: the howl of a wolf. Álvares smiles and nods, then walks toward the sound, into the darkness of the trees.

"A wolf pack has denned in the hills above town for at least a decade," he says in a low voice as we walk. "They pick off village dogs, goats, and calves when they can catch them. Some years back they swept through town in the middle of the night, rounded up a donkey that had been left untied, drove it out of the village, and killed it."

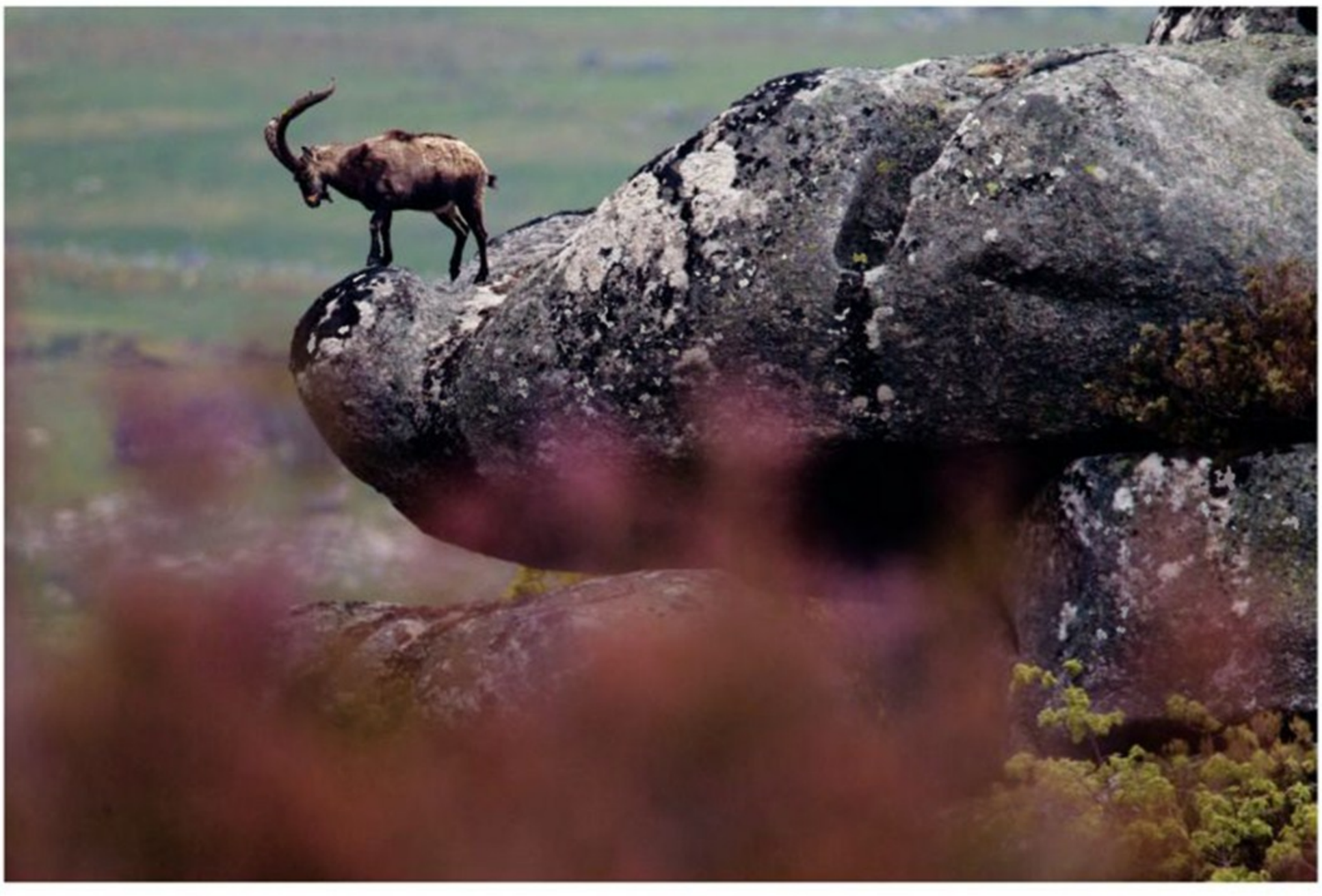
The village of Pitões das Júnias is in Peneda-Gerês, Portugal's first and only national park. At 270 square miles, it's small compared to sprawling parks such as Yellowstone, the world's first national park. But packed within its borders is a highly concentrated mixture of things wild and domesticated. Forty endangered Iberian wolves share the terrain with some 11,000 people, who live in more than 80 settlements formed long before the park was established in 1971. In fact, people and wildlife have lived in close proximity here since the Stone Age. Whether they exist today in delicate equilibrium or constant tension depends on whom you ask.

Tucked into a craggy corner of northern Portugal, hard against the Spanish border,



Windowpane clear and bracingly cold, the Homem River and other swimming spots draw thousands of visitors to Peneda-Gerês on summer weekends. The seasonal invasion challenges the park's year-round residents and wildlife.





Straddling the border between northern Portugal and Spain, this realm of plunging waterfalls and sheer rocky gorges has been recolonized by the Iberian wild goat. The first goats crossed the border from a contiguous park in Spain about a decade ago and now number a hundred individuals.





NGM MAPS
SOURCES: PENEDA-GERÊS NATIONAL PARK; UNIVERSITY OF MINHO

Perched on stone posts to keep mice at bay, traditional corncribs and their nearby threshing floors have been centers of agricultural life since the 17th century—shortly after Portuguese and Spanish explorers brought back corn from the New World.





Peneda-Gerês is carved by mountain ranges, rivers, canyons, gorges, and streams. Most villages are situated in the lower valleys, where the climate is milder and the terrain more accommodating to people and livestock. The park's wild heart is in the high country, a realm of rugged granite massifs, windswept moors, and bare uplands greened in places by stands of giant holly.

Álvares and I walk through the darkening forest surrounded by smells of moss, fern, and loam and the sound of flowing water, a constant companion in Peneda-Gerês. It rains more than a hundred days a year here, and many springs rise clear and cold in the highlands, seeping into peat bogs or flowing down the mountains in a crescendo of streams, rivers, and waterfalls.

The landscape has also been shaped by human beings, who have lived here since the Neolithic —as evidenced by massive rock monuments, called dolmens, that dot the moors. A Roman road traverses the forest, and medieval castles perch on rocky peaks. Elaborate terraced fields climb the hillsides where farmers have grown corn and wheat for centuries. Walk along a winding river course and you may come upon an abandoned monastery where generations of monks prayed and fasted or a shrine that still draws pilgrims. Many of these structures, lichen-patched and rain-smoothed and built from local rock, match their surroundings so well they seem to have grown up organically from the soil.

This harmony of landscape and history, of wilderness and civilization, has been strained in recent decades by the construction of vacation

Author Tom Mueller writes from his home in the north of Italy. Photographer Peter Essick is a regular contributor to National Geographic.



Lindoso Castle was a key stronghold during the 17th-century battles that led to Portugal's independence from Spain. Like their herders, local cattle (opposite) are well adapted to the harsh landscape.

homes and hydroelectric dams inside the park, and one of the largest wind farms in Europe just outside the park's western border. Whether the park can endure this onslaught of modernity is a hotly debated question in local cafés, though it receives little attention in Lisbon.

As dusk turns to darkness, Álvares snaps on an infrared headlamp and we continue hiking into the hills. After 20 minutes of climbing, we emerge on the granite highland. Álvares howls a few more times, but the wolves that den up here are nowhere to be seen or heard.

We roll out our sleeping bags in a little grassy swale among the boulders. The stars are out, brilliant as a desert sky, the Milky Way dense and luminous. Three or four times during the night the wind picks up, fog blows through, and light rain falls. Sudden weather changes are common, especially in the highlands.

The next morning we wake to the thump of hooves. A semiwild stallion paws the ground and looks at us suspiciously while his herd grazes behind him. The sky is brilliant blue, and in the orange glow of morning every outline—the crags around us and the higher peaks westward, the forests to the east and south, even the distant turbines of the wind farm—have a fresh-minted sharpness.

Many parks celebrate pure nature, but Peneda-Gerês is memorable for its juxtapositions—wolf dens within sight of human homes, ancient villages in the shadow of wind turbines. If the park's delicate balance ever fails, the world will lose a treasure far out of proportion to its size. □

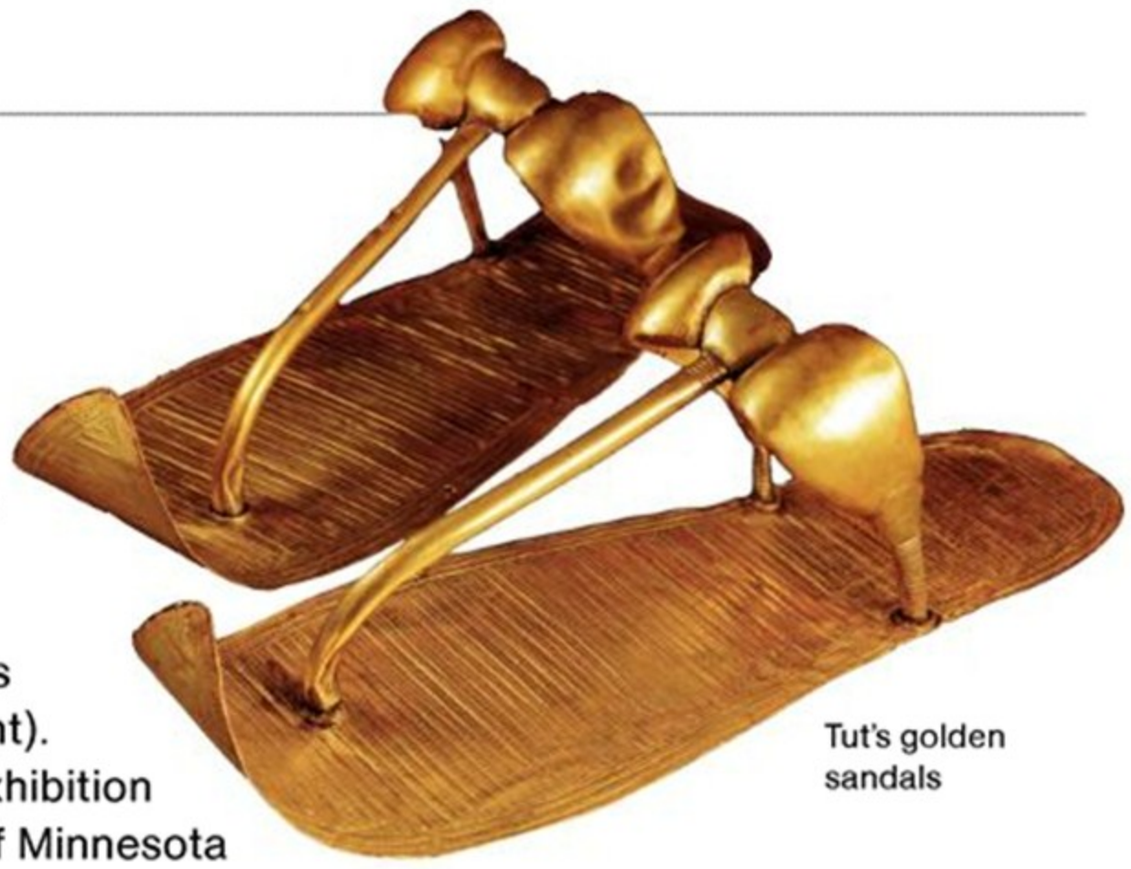
NG CONNECT

Every month this page features our staff picks for National Geographic Society happenings. For more information go to *nglive/events.org.*

EXHIBIT

King Tut in Minnesota

Step into the world of the pharaohs. Ancient history and modern science combine for an up-close perspective on artifacts, including the golden sandals from King Tut's mummy (right). This National Geographic exhibition is at the Science Museum of Minnesota through September 5, 2011. Go to *smm.org/tut* for ticket information.



Tut's golden sandals

WORKSHOP



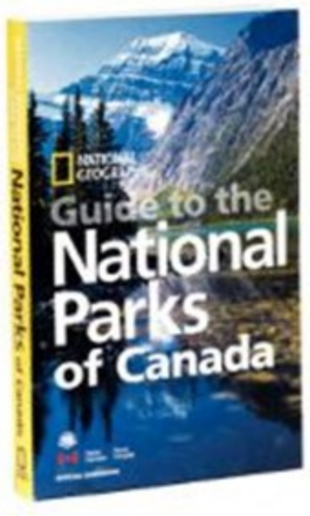
SANTA FE Shoot like the pros in Santa Fe, New Mexico. Our seven-day workshop is for amateur photographers who want to improve their digital skills with the help of Geographic experts. Joe McNally will join July's workshop. Amy Toensing will join October's. Go to *nationalgeographic expeditions.com/santafe.*

APP

HANDHELD BIRDS Our best-selling field guide to North American birds is available for your iPod touch or iPhone. Search more than 1,600 detailed images and listen to nearly four hours of birdsong. Download at the App Store now ($9.99).

BOOK

CANADA'S PARKS Lace up your hiking boots and grab the complete guide to Canada's national parks. Packed with photos, maps, itineraries, and advice from expert travel writers, our guide gives you everything you need for an adventure in the Great White North. In stores now ($26).



Free Download of the Month



Natacha Atlas and Basha Beats

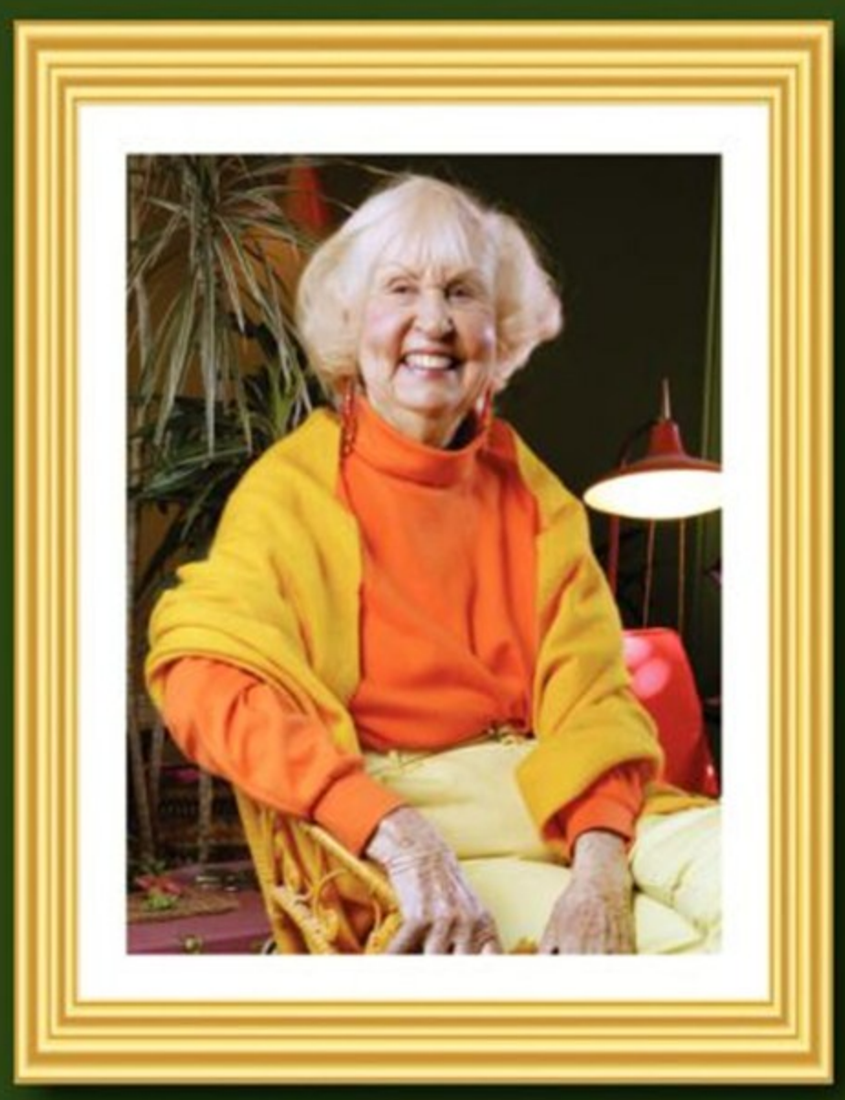
When Egyptians took to Tahrir Square to cheer the end of Hosni Mubarak's 30-year presidency, Belgian-Egyptian musician Natacha Atlas (left) took to her studio. She collaborated with producer Basha Beats on "Batkallim," a song that celebrates Egyptian democracy. To download go to *natgeomusic.net/free.*

PHOTOS (FROM TOP): SANDRO VANNINI; RYAN HEFFERNAN, SANTA FE PHOTOGRAPHIC WORKSHOPS; REDOZ MUSIC

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NATIONAL GEOGRAPHIC

Give An *Inspiring* Gift



Pat Minnick included National Geographic in her financial plans.

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic.

"I feel good knowing that National Geographic is doing so much to protect endangered wildlife," says Pat. "The environmental problems we face are vast, but by joining with National Geographic and their history of remarkable accomplishments, I know we can pass on a more beautiful world."

Pat now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

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Photo: Nel Cepeda

The Televised Revolution As protesters raged in Cairo's Tahrir Square in early February, photographer Lynsey Addario saw it all unfold—on television, in Baghdad. She longed to leave Iraq to cover the breaking story but still had to finish her assignment. So she went out into the city to experience Egypt's revolution as the Iraqis were doing. At a Baghdad barbershop she found Jalal Khalil (in pink) and his customers following the news. "I was absolutely tortured watching Egypt and the fall of Mubarak on television," says Addario. "I have been covering the Middle East and South Asia for 11 years now, and while Egypt in particular wasn't my story, it was extremely difficult to watch history being made on TV. I am used to being in the middle of it!" *—Margaret G. Zackowitz*



BEHIND THE LENS

Lynsey Addario soon was in the middle of it.

Over the next few weeks Addario traveled from Afghanistan to Egypt to Bahrain to Libya, where on March 15—on assignment for the *New York Times*—she was taken captive at gunpoint by Libyan government forces near the city of Ajdabiya. Apprehended with her were fellow photographer Tyler Hicks, reporter Stephen Farrell, and the *Times*'s Beirut bureau chief, Anthony Shadid. The journalists, often bound and blindfolded, were shuttled from place to place for three days. No one outside Libya knew their whereabouts. They endured beatings and other abuse from their captors. Finally the group was put on a plane to Tripoli, where diplomatic negotiations for their release got under way. The four were held in a safe house until March 21, when they were transported across the Libyan border to Tunisia—and at last to safety.

Beauty is **timeless.**



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Stalk King Alaskans may grow little produce, but some of that little grows big. The long days of summer sunlight there help some rhubarb plants—the first of which were likely introduced to the region by Russian traders in the 1700s—reach heights of five feet or more.

In the early 20th century Henry Clark (above, in 1921) of Skagway, Alaska, was known as the Rhubarb King for his monster crop. Rhubarb stalks (and only stalks—the leaves and roots are toxic) like his provided vitamins, fiber, and flavor to Klondike gold rush hopefuls who had few other options for fresh produce that far north. Today descendants of Clark's rhubarbs still thrive for Skagway resident Charlotte Jewell, who runs a garden business on the site of his old farm. "Our town became famous for its rhubarb," she says, "and Henry Clark started it all." *—Margaret G. Zackowitz*

Flashback Archive Find all the photos at **ngm.com.**

PHOTO: ASAHEL CURTIS, NATIONAL GEOGRAPHIC STOCK

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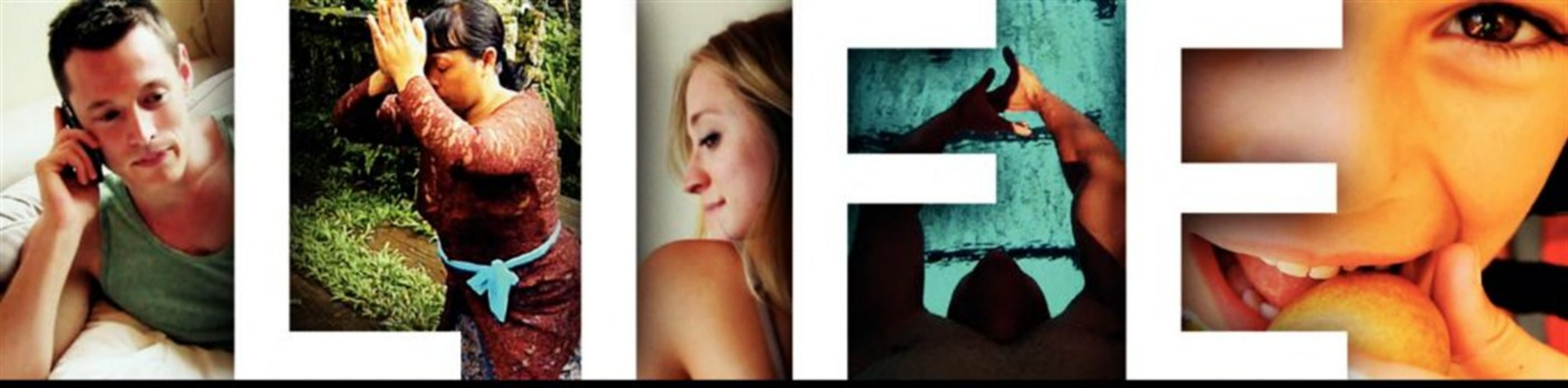
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